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ADVANCED STANDOFF INTERDICTION WEAPON AND SENSOR SYSTEM. VOLUME I

RCA Service Company

Prepared for:

Advanced Research Projects Agency

15 June 1972

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ADVANCED RESEARCH PROJECTS AGENCY

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ADVANCED STANDOFF INTERDICTION WEAPON AND SENSOR SYSTEM (U)

Volume I

15 June 1972

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Prepared by

RCA Service Company

at the Direction of

Range Measurements Laboratory

Patrick Air Force Base

Florida

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ADVANCED STANDOFF INTERDICTION WEAPON AND SENSOR SYSTEMS (U)

Volume I

15 June 1972

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ABSTRACT

(C) The ARPA NITE GAZELLE Advanced Standoff Interdiction Weapon and Sensor Systems were tested at Nellis Air Force Base, Nevada, between 10 February 1970 and 2 February 1972. Over three hundred flights of the remotely piloted NITE GAZELLE helicopter were conducted in the reconnaissance/strike configuration to determine the feasibility of the NITE GAZELLE concept. In Nellis testing, the NITE GAZELLE helicopter was remotely piloted to a specified target area, a specific target was acquired and identified on a television monitor and the weapon or sensor system was operated according to a predetermined test scenario. The operational range of the helicopter was extended to beyond ground line of sight using the Grand View Relay System. The Egyptian Goose long range radar system was used to detect targets and vector the helicopter to the general target area. The Egyptian Goose was also used directly by the pilot for control against ground truth reference maps.

(C) Four reconnaissance/strike and two sensor configurations of the NITE GAZELLE were tested at Nellis. In these tests, the remotely piloted helicopter was flown at airspeeds from a near hover to 64 knots and at various altitudes from 50 to 3,000 feet at ranges up to 24 miles from the ground control point. The four reconnaissance/strike vehicles were:

1. The Day/Night Laser Aided Rocket Weapon System
2. The Day Hypervelocity Gun Weapon System
3. The Day Bomblet Dispenser Weapon System
4. The Day Grenade Launcher Weapon System

The sensor systems were:

1. The Moving Target Radar (PPS-5)/Day Television System
2. The Blow Low Electro-Optical Day/Night System

(C) The Laser Aided Rocket System demonstrated the capability of the Proportional Lead Guidance System to guide a missile from a launch slant range greater than 6,000 feet to impact on the laser spot. During the early part of this program, target boards and stationary tactical type targets were illuminated by a laser illuminator located on the ground in front of the targets. Later in the program, a tracking mount for the helicopter was developed that provided an airborne laser pointing accuracy of $\pm$ 0.2 milliradian. This configuration was used to produce direct hits on stationary and moving tactical type targets during day launches. Laser illuminator performance provided the capability to launch missiles from a standoff range of over 8,000 feet. Night launches were not successful because low light level television problems caused the contrast tracker to lose lock and allow the laser spot to drift away from the target. Improved launching techniques are possible which will compensate for this problem.

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(C) The Hypervelocity Gun Weapon System tests demonstrated a one-sigma dispersion of one milliradian at the target when firing at ranges of 1,500 feet.

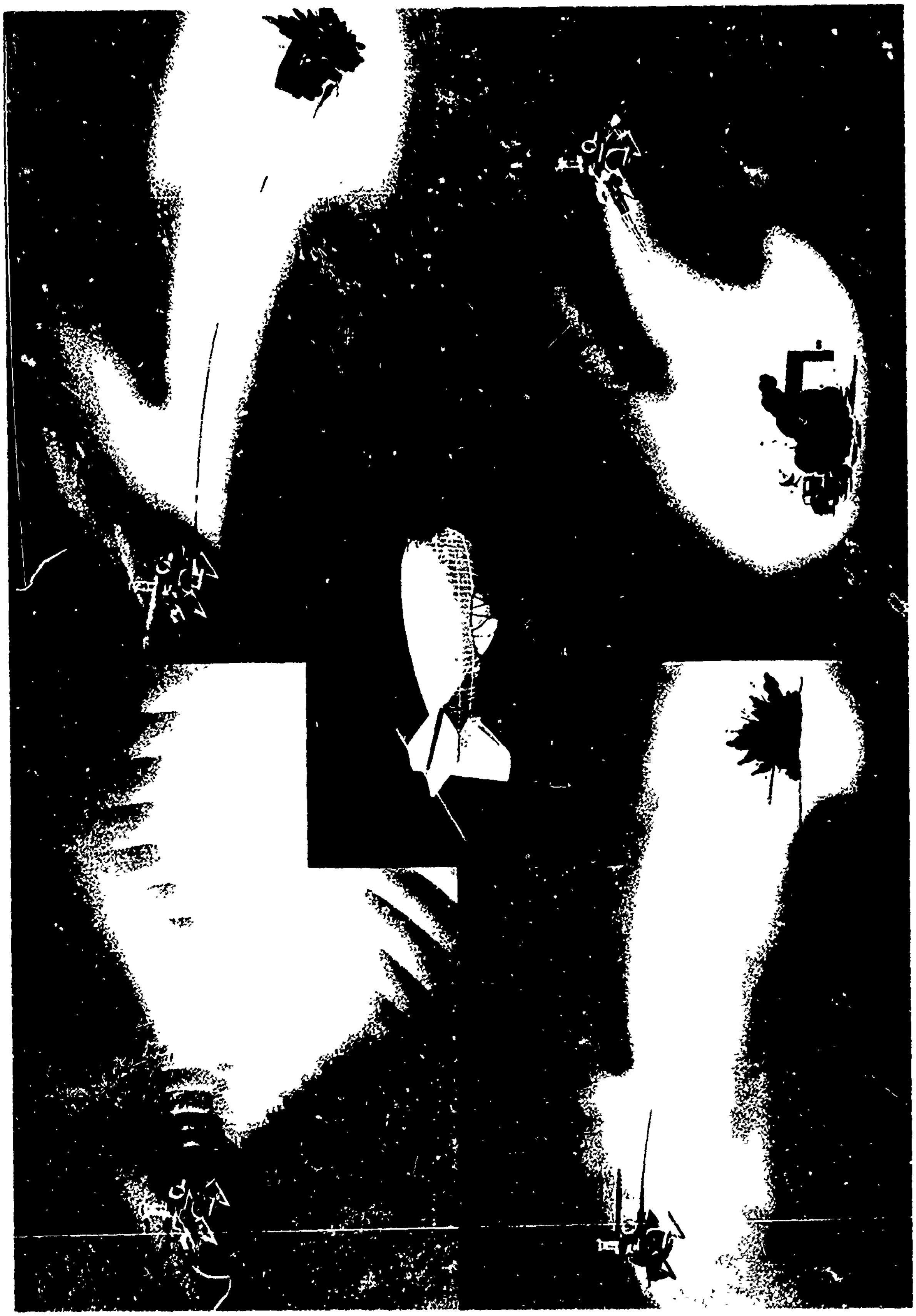
(C) The Bomblet Dispenser Weapon System demonstrated a capability to provide area target coverage 40 x 170 feet. Deliveries were made from altitudes of 600 to 3,000 feet against target grids.

(C) The Grenade Launcher Weapon System demonstrated a one-sigma dispersion of 4.2 mils. Launches were made at altitudes of 500 to 3,000 feet against target boards and stationary trucks. Direct hits on stationary trucks from an overhead altitude of 1,000 feet were achieved.

(C) The Moving Target Indicator Radar System consistently achieved vehicle detection at a range of 9.5 kilometers, personnel group detection at 8.5 kilometers and detection of one individual at 7.5 kilometers. Targets were located to an accuracy of 100 meters and helicopter position was determined to within 100 meters.

(C) Use of the Grand View Relay System to relay command, television and telemetry signals to operate the NITE GAZELLE vehicle at a range of 40 statute miles from the remotely operated relay station was demonstrated. Television signals transmitted over a distance of 100 miles were received and relayed 16 miles to the ground control station without degradation or distortion.

(C) The use of the Egyptian Goose Radar System to: 1) detect targets, and 2) to navigate the NITE GAZELLE vehicle to the target intercept was demonstrated to an accuracy of (1) $\pm$ 1.0 degree in azimuth, and (2) $\pm$ 150 feet in range. Overall resolution performance achieved was 150 feet in range and 160 feet in azimuth at a radar to target array range of 19 miles. Beacon MTI was demonstrated in conjunction with a passive MTI test program for mine field mapping.



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PREFACE

(C) The ARPA NITE GAZELLE Advanced Standoff Interdiction Weapon and Sensor Systems consist of remotely piloted helicopters outfitted with a variety of sensors and weapons for detection, location, identification and precision kill of enemy logistic transportation targets, fixed hard targets and personnel during the day and under low light level conditions of night. The NITE GAZELLE is an effective hunter and killer that provides an action radius of 100 miles, up to one hour on station time, a standoff distance of over 8,000 feet and delivery accuracy of less than one milliradian for selected weapons.

(U) This report presents an introduction of the concept of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems and a summary of the test results on the various configurations. This is followed by a short summary describing the significant events for each system tested at Nellis Air Force Base, Nevada. The individual sub-volumes of this report provide a detailed description of system operation, test objectives, test plans, summarized test results and a report for all completed tests. The weapon and sensor systems discussed in the report appear in the following order: Moving Target Indicator Radar (PPS-5) System, Laser Aided Rocket System, Hypervelocity Gun Weapon System, Bomblet Dispenser Weapon System, Grenade Launcher Weapon System, Grand View Relay System and the Egyptian Goose Radar System. The Blow Low Electro-Optical Sensor System, because of classification differences, is discussed in Volume II.

(U) The material used to prepare this report was obtained from participating contractors, individuals associated with the specific technologies involved, published and unpublished reports, recorded impact data, video tape records, photographic records, telemetry records and other test data recorded at the Nellis test site.

(U) The following organizations are recognized for their many helpful suggestions and support:

Naval Air Systems Command (NASC), Washington, D. C.
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USAF Aeronautical Systems Division (ASD), Wright Patterson, Ohio
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North American Rockwell, Columbus, Ohio
RCA Service Company, Patrick Air Force Base, Florida
Thompson Ramo Woolridge, Redondo Beach, California
Westinghouse, Baltimore, Maryland

TABLE OF CONTENTS

1.0 INTRODUCTION

(C) The ARPA Advanced Standoff Sensor and Weapons were conceived as an interdiction system to counter enemy logistics networks supporting deployment of forces in tactical warfare operations such as seen in the South-east Asian type theater. Four functions are necessary to assure the success of this operation. First, continuous real time observation of enemy territory is necessary to detect and locate movement of supplies, weapons, troops and vehicles. Second, these targets must be tracked in real time in order to see enemy plans developing, to minimize the vulnerability of the sensor/weapon system and to maximize the kill potential of the system. Third, positive identification of the suspected target is mandatory. Finally, precision kill of the target with a minimum of expended weapon weight is desired.

(C) Several hardware systems were envisioned by ARPA to effectively perform these four functions with operations and observer personnel located at a safe, standoff distance. The weapon and surveillance vehicles that have been developed will be discussed later in this report.

(C) A radar system would appear to be the obvious solution to the continuous real time observation problem. However, ground based systems have a limited potential for observation of distant land targets. Radar systems mounted in aircraft can satisfy the distance requirement but their ability to provide continuous surveillance of a specific area is limited because of the high speed of the aircraft. The ARPA solution to this problem was to provide a remotely controlled radar system (Egyptian Goose) carried aloft by high altitude balloons or located on strategic terrain. This radar system provides the dual function of surveillance and tracking twenty-four hours per day while the observers are located at a safe standoff distance.

(C) Suspect targets which have been acquired by the surveillance radar must be intercepted and identified. High resolution daytime television systems, low light level television systems for night operations, laser and infrared illuminators and short range radar systems (AN/PPS-5) were developed to insure that friendly targets are not destroyed. These same systems can be used to reconnoiter potential target areas.

(C) The NITE GAZELLE weapon systems were conceived to destroy specific target types. The Grenade Launcher can saturate an area with shrapnel. The Bomblet Dispenser, by firing one pair of tubes, can cover an area 40' x 170' with anti-materiel and anti-personnel fragments. These systems could effectively be used to eliminate enemy troops scattered throughout an area.

(C) Where there are individual and specific targets, the LARS and Hypervelocity Gun systems can be used most effectively. The Hypervelocity Gun can destroy trucks by impacting one round in the engine block. The LARS

can also destroy a truck with the expenditure of only one round. Since the cost of a LARS is much greater than a Hypervelocity Gun flechette, target costs would be considered in making a weapon selection. In general, the LARS would be used for tanks, material storage areas and other costly targets. Range to the target is also an important consideration in weapon selection. Since the effective range of the LARS is approximately three times greater than the Hypervelocity Gun it may be necessary to expend a LARS to destroy targets that could not be approached by other weapon systems.

(C) These weapon and sensor systems are delivered to target areas by remotely controlled helicopters. The normal useful range of the helicopters can be extended by relaying commands and response data through a remote, unattended (Grand View) relay station. Navigation of the helicopter and interception of the target is improved by displaying target and helicopter information derived from the surveillance radar system on a TV monitor located at the ground control station.

(C) The versatility of these weapon and sensor systems provides the opportunity for field commanders to observe enemy movements from a safe, standoff distance, select the point of interception, plan the type of action to be taken and select the most appropriate weapon and sensor system to effectively complete the mission.

(U) The remotely piloted helicopter was tested in the area about the Gyrodyne Company plant. The limited area available at this facility prevented distant flights to exercise the full capability of the helicopter. Some individual weapon subsystems had been ground tested at other military test sites. In order to confirm the operational feasibility of the planned weapon and sensor combinations, an operational environment was selected where live weapons could be fired.

(U) Arrangements were made to accomplish the operational feasibility testing at Nellis Air Force Base (Range 3), Nevada, and the first weapon system was placed under test in February, 1970. Testing at Nellis was completed in February, 1972. The overall program test schedule is shown in Figure 1.

(C) In addition to the tests conducted on individual weapon and sensor systems, several combinations were tested. The Grand View Relay System was used to fly the helicopter beyond the ground line of sight by relaying helicopter control and sensor response data to the ground control station. The on board sensor systems observed landmarks and searched for targets in designated areas. The weapons were dispensed and the helicopter was returned to its launch area. Results of the test were available in real time. The Egyptian Goose Radar System was used to locate targets and vector the helicopter to intercept them while the helicopter was being controlled through the Grand View Relay System. This combination of systems demonstrated the capability

(C) to detect, track and destroy targets at a distance of over 100 nautical miles.

(U) The individual test programs described in the sub-volumes of this report are in the following order: MTI Radar (PPS-5), Blow Low (VolumeII), LARS, Hypervelocity Gun, Bomblet Dispenser, Grenade Launcher, Grand View Relay and Egyptian Goose Radar. A summary of results on each of these test programs is given in the following section (Section 2).

(U) NELLIS TEST PROGRAM DATES

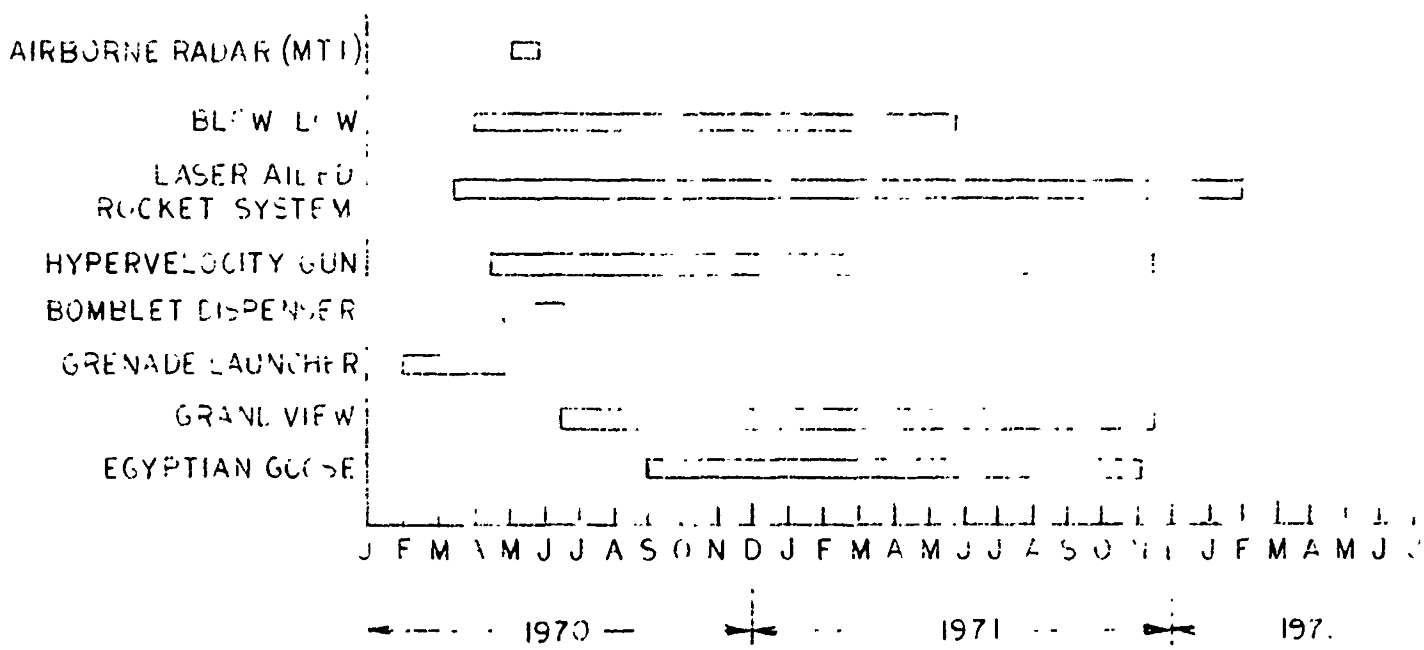

FIG. 1

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2.0 RESULTS

(C) The NITE GAZELLE remotely piloted helicopter proved to be an effective carrier of the ARPA Advanced Standoff Weapon and Sensor Systems. The results of weapon and sensor testing demonstrated that performance met or exceeded design expectations. More detailed test plans, objectives and results of all systems tested. except Blow Low, are presented in sections 4 through 11 of this report. A summary of test results of each program is presented in Table 1. below. A NITE GAZELLE helicopter performance summary is given in Figure 2. A chronological summary of significant events is presented in Table 2.

TABLE 1 (Title Unclassified
Table Confidential)

PROGRAM SUMMARY

Program	Test Dates	No. of Tests	Summary of Test Results
MTI Radar (AN/PPS-5)	From: 5/7/70 To: 5/21/70	35	Vehicle detection range was determined to be 9.5 km. Group detection range is 8.5km. Individual detection range is 7.5km. Helicopter location accuracy is 160 meters. Target location accuracy is 100 meters.
LARS I	From: 3/11/70 To: 5/11/70	24	Six guided missiles were launched. Two were not successful because of roll control problems. Impact of the others occurred from one to eleven feet from the target center.
LARS II	From: 11/18/70 To: 11/4/71	29	Nine guided missiles were launched. Two were not successful; one because of TV problem and the other because of a guidance problem. A direct hit was made on a moving tank. Largest miss distance was 10 feet right and 10 feet up.
LARS II (Night)	From: 9/1/71 To: 2/2/72	33	Two guided missiles were launched. Both were unsuccessful because of low light level television problems.
Hyper-velocity Gun	From: 4/21/70 To: 11/24/71	22	Contrast tracker accuracy was determined to be $\pm .5$ mil. Boresight and calibration firings demonstrated a ± 1.0 mil dispersion.

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Table 1 Continued

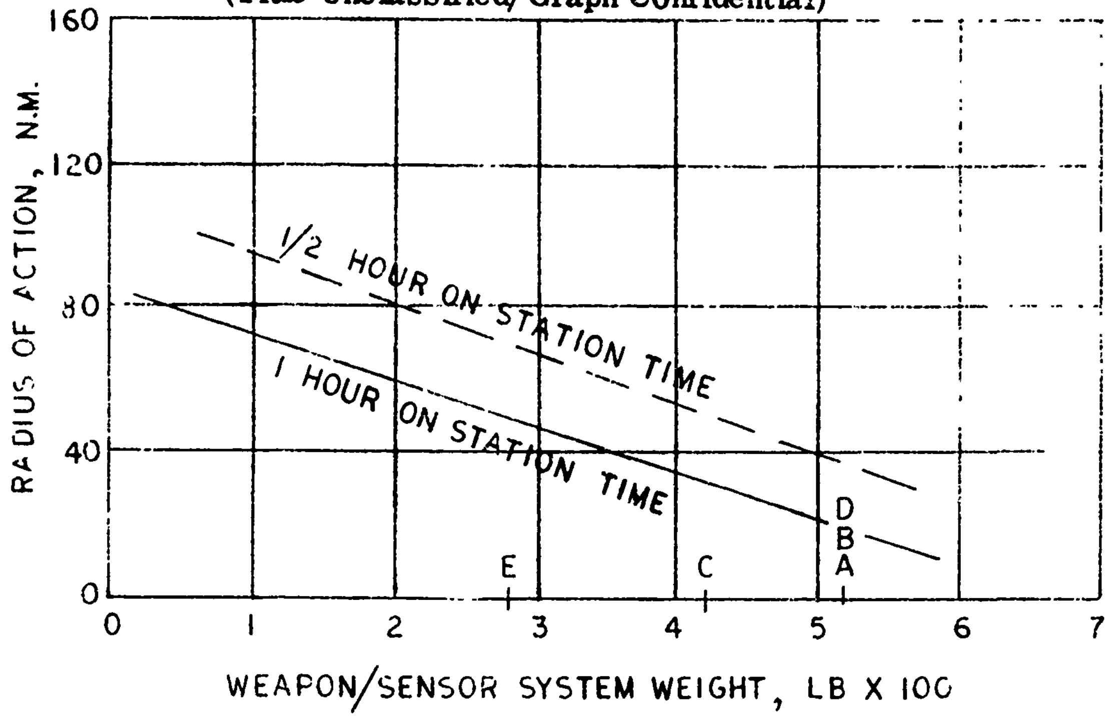
Program	Test Dates	No. of Tests	Summary of Test Results
HV Gun Continued			Limited flight testing shows a ± 1.0 mil dispersion. 316 flechettes were fired.
Bomblet Dispenser	From: 3/6/70 To: 6/11/70	12	BLU-3, BLU-24 and BLU-26 bomblets were tested. A total of about 1700 bomblets were dispensed. The average impact pattern measured 40 x 170 ft. Freshly packed BLU-3 bomblets had the lowest dud rate (9%).
Grenade Launcher	From: 2/10/70 To: 5/5/70	37	Firings conducted from the "Big U" mount resulted in a one sigma standard deviation of 4.2 mils. Limited Twin Turret mount tests resulted in a dispersion of 20 mils. Over 500 grenade impacts were scored.
Grand View Relay System	From: 6/18/70 To: 11/12/71	39	Television signals transmitted over a distance of 100 miles were received and relayed 16 miles to the ground control station. Continuous relay of helicopter command, telemetry and television signals was provided by the system while the helicopter was flown in the pad area and on extended range flights.
Egyptian Goose Radar System	From: 9/1/70 To: 11/12/71	22	Range resolution was determined to be 150 ft. Azimuth resolution was 160 ft. Range accuracy was ± 150 ft. and azimuth accuracy was $\pm 1.0°$. Testing indicated that a 2 1/2 ton truck type target can be dete· ted at a range of 100 miles.

(C) During the two year test program at Nellis, over three hundred flights were flown with the NITE GAZELLE helicopter. Several missions were aborted in flight because of helicopter airframe or control problems, but there were no helicopter losses. Total flight time was approximately 200 hours. The average time required to repair helicopter problems was 111 minutes. The minimum reported repair time was 30 minutes, the maximum reported time was 480 minutes, and the median repair time was less than 90 minutes.

(U) The tactical radius and the on station time of a fully fueled helicopter depends on the weight of the weapon or sensor system. Figure 2 shows the

NITE GAZELLE PERFORMANCE SUMMARY

(Title Unclassified/Graph Confidential)



(U) This performance graph was completed for a helicopter with 20 foot rotors having a cruise speed of 60 knots. The action radius is dependent on the total airborne weight. The letters on the graph show the weight of the following weapon and sensor systems:

- A Laser Aided Rocket System
- B Hypervelocity Gun Weapon System
- C Bomblet Dispenser Weapon System
- D Grenade Launcher Weapon System
- E Moving Target Indicator Radar System

Figure 2

tactical radius of the NITE GAZELLE Weapon and Sensor Systems tested at Nellis Air Force Base.

(U) The significant events of the Nellis test program are arranged in chronological order in Table 2. A test number is included so that reference may be made to the test report for that event.

TABLE 2 (Title Unclassified
Table Confidential)

CHRONOLOGICAL SUMMARY OF EVENTS

Date	Significant Event
Feb. 70	NITE GAZELLE test operations began at Nellis AFB, Nevada.
2/12/70	Grenades were successfully fired at stationary targets. (Grenade Launcher Test No. 1)
3/11/70	Bomblet drops were successfully conducted. (Bomblet Dispenser Test No. 14A)
4/15/70	Guided LARS I missile impacted only one foot from center of stationary target from range of 4,800 feet. (LARS Test No. 31B)
4/22/70	Contrast Tracker tracking accuracy of .5 mil was demonstrated on a moving truck target. (Hypervelocity Gun Test No. 70A)
5/5/70	High explosive grenades successfully fired at stationary trucks. (Grenade Launcher Test No. 42)
5/8/70	Truck detected at 9.5 km by airborne MTI radar. (PPS-5 Test No. 50)
5/15/70	Three men walking detected at 9.3 km by MTI radar. (PPS-5 Test No. 55)
5/19/70	One man walking detected at 7.5 km by MTI radar. (PPS-5 Test No. 56)
5/20/70	Targets successfully located to 100 meter accuracy by MTI radar. (PPS-5 Test No. 59)
5/25/70	Blow Low Sensor demonstration. (Blow Low Test No. 103)
6/27/70	Daytime operation of Blow Low sensors demonstrating operational readiness (Blow Low Test No. 111D)

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Table 2 Continued

Date	Significant Event
7/14/70	Nighttime operation of Blow Low sensor demonstrating operational readiness. (Blow Low Test No. 114)
7/23/70	Television and telemetry signals from helicopter were successfully relayed through Grand View. (Grand View Test No. 152)
8/14/70	Good TV video transmitted over a distance of 100 miles was received and relayed 16 miles to the ground control station. (Grand View Test)
9/29/70	Egyptian Goose radar resolution of 1500 feet in range and 160 feet in azimuth was attained. (Egyptian Goose Test)
10/13/70	Vehicles were detected when radial velocity exceeded 2.5 mph. (Egyptian Goose Test)
11/17/70	The NITE GAZELLE helicopter was successfully vectored to intercept stationary and moving targets using the Egyptian Goose radar. (Egyptian Goose Test No. 220)
12/15/70	The NITE GAZELLE helicopter was successfully flown by command signals relayed through Grand View.
5/20/71	Hypervelocity Gun system accuracy of 1.00 mil was attained in flight test using the fire control computer. (Hypervelocity Gun Test No. 243)
11/4/71	A guided LARS missile using the airborne target designator hit the laser spot on a stationary tank target from a range of 6,200 feet. (LARS Test No. 356)
11/4/71	A guided LARS missile using the airborne target designator scored a direct hit on a moving tank target from a range of 5,500 feet. (LARS Test No. 357)
11/11/71	The NITE GAZELLE was flown on an extended range flight of 40 miles from the relay station. The Egyptian Goose radar was used for position information. (Grand View and Egyptian Goose Test Nos. 343 and 347)
2/2/72	NITE GAZELLE test operations were completed at Nellis AFB, Nevada with the launch of a LARS at night. (Test 429)

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3.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations for the following programs:

Moving Target Indicator Radar (AN/PPS-5) System
Laser Aided Rocket System
Hypervelocity Gun Weapon System
Bomblet Dispenser Weapon System
Grenade Launcher Weapon System
Grand View Relay System
Egyptian Goose Radar System

3.1 Moving Target Indicator Radar (AN/PPS-5) System

3.1.1 Conclusions

(C) Nellis testing demonstrated the compatibility of the radar and helicopter systems. Radar detection ranges for vehicle, group and individuals were 9.5, 8.5 and 7.5 kilometers respectively. Television identity ranges for vehicles, groups and individuals were 5.0, 2.0 and 1.0 kilometers respectively. Target locations were determined to an accuracy of ±160 meters. Helicopter locations were determined to an accuracy of ±100 meters.

(C) Radar detection ranges were in all cases, greater than television identification ranges. Use of the improved tracking mount developed for other NITE GAZELLE programs would provide a stable platform for a longer focal length television lens and identification distance would be increased. The television system could not be used at night.

(U) The system met all test objectives but overall performance could be improved by increasing the radar power and providing a computer capability to use actual helicopter altitude to compute ground range.

3.1.2 Recommendations

(U) A study should be conducted to determine the optimum television optical system to be used on the improved tracking mounts during both day and night operations.

(U) The radar transmitter power should be increased by at least an order of magnitude to increase the blip-to-scan ratio and increase the necessary background clutter.

(U) The existing coordinate converter should be replaced with a general purpose computer capable of using actual helicopter altitude in the computation of ground range.

3.2 Laser Aided Rocket System

3.2.1 Conclusions

(C) Ground and airborne laser illuminators were effectively used to illuminate various target types for missiles launched at helicopter-to-target ranges of 4800 feet to 8100 feet.

(C) The proportional lead guidance system demonstrated the capability to produce direct hits on the laser spots at these ranges. The airborne laser illuminator was successfully used to produce direct hits on stationary and moving tactical type targets during day launches. The system capability for night launches was demonstrated but low light level television problems caused the laser spot to drift away from the target and the missile followed the spot. Improved launching techniques should eliminate this problem.

(C) At the beginning of the program airborne laser pointing accuracy was ±1.0 milliradian. Tracking mount improvements resulted in a tracking accuracy of ±0.2 milliradian, but with a 230 pound increase in mount weight. Overall mount weight could be reduced by using solid state power supplies and by miniaturizing the electronic control circuits.

(C) The helicopter and ground control station provided satisfactory support for this test program.

3.2.2 Recommendations

(C) Additional testing should be conducted at night to evaluate various launching techniques and equipment modifications in order to achieve a successful night capability.

(C) A study should be conducted to evaluate the advantages versus cost of reducing the weight of the tracking mount.

3.3 Hypervelocity Gun Weapon System

3.3.1 Conclusions

(C) NITE GAZELLE/Hypervelocity Gun System feasibility was demonstrated in air-to-surface firings at a range of 1500 feet from a stationary bull's-eye target. Using the Contrast Tracker/Fire Control Computer, a one-sigma standard deviation of 1.00 mil resulted about a centroid .49 mil from the target center.

(C) Defective ammunition is degrading system accuracy and potential weapon effectiveness. Results obtained from hardstand firings showed that 17% of the rounds fired were either wild or they tumbled. Tumbling rounds have less penetration, since they hit the target sideways.

(C) Plastic buildup in the gun barrel, from the plastic sabots, may be degrading system accuracy. Accuracy improved after cleaning the gun barrel.

(C) Hardstand firings were conducted with the gun barrel restrained by a shroud to reduce the effect of recoil vibrations. A comparison of test results obtained from hardstand made without any restraints on the barrel show that the best accuracy was obtained with an unrestrained barrel, firing single rounds and allowing the gun barrel recoil vibrations to damp out prior to subsequent firing.

(C) When the tracking mount is adjusted to lead a moving target, or whenever it is adjusted to correct for gravity drop, an undesirable consequence is that the laser aiming is adjusted an equal amount, since the laser range finder is rigidly fixed to the tracking mount. This adjustment will often be large enough to move the laser spot off the target. Erroneous range information results and the Contrast Tracker/Fire Control Computer system becomes inoperative.

3.3.2 Recommendations

(C) Improved ammunition should be obtained.

(C) The gun barrel should be frequently cleaned to remove plastic buildup.

(C) A means of independently aiming the laser ranger and the Hypervelocity Gun should be devised. If the ranger was kept on the target during lead and gravity corrections by the weapon aiming system, larger target speeds and gravity corrections could be tolerated without excessive range errors.

3.4 Bomblet Dispenser

3.4.1 Conclusions

(C) The XM-18 dispensers are compatible with the NITE GAZELLE helicopter. Forty-four successful bomblet drops were executed in twelve missions.

(C) The NITE GAZELLE helicopter provides an adequate delivery system for BLU-3 and BLU-24 bomblet types.

(C) System feasibility was demonstrated in flight testing over a grid area. Impact patterns ranged in size from 80' x 30' to 280' x 50' with the average being 170' x 40'.

(C) The altitude and ground speed at which the bomblets are dispensed affect bomblet trajectories. Bombing accuracy can be increased by using tables of altitude and ground speed versus drop point.

(C) Real time observation of bomblet impacts is not possible with the present mount limitations of -100 degrees in depression. This situation occurs because the bomblets are ejected toward the rear of the helicopter, and since several seconds elapse prior to impact, the helicopter has meanwhile moved

too far forward to observe bomblet impacts with the present mount limitation.

3.4.2 Recommendations

(C) Tables of altitude and ground speed versus drop point should be compiled to increase bombing accuracy.

(C) The mount limitation of -100 degrees should be extended, if possible to permit real time observation of bomblet damage.

3.5 Grenade Launcher

3.5.1 Conclusions

(C) The XM-129 grenade launcher is compatible with the NITE GAZELLE delivery system and the NITE GAZELLE/Grenade Launcher offers excellent potential as a weapon system. Air-to-surface firing at stationary CBU grid targets resulted in a one-sigma standard deviation of 4.2 mils about the centroid of each firing burst. Aiming accuracy can be increased through the installation of a fire control computer.

(C) System effectiveness was demonstrated in air-to-surface firing of live rounds against stationary truck targets at an overhead altitude of 1,000 feet. Several hits were recorded on film and extensive damage to the trucks is evidenced by pre and post mission motion pictures.

3.5.2 Recommendations

(C) A fire control computer should be installed where additional aiming accuracy is desired.

3.6 Grand View Relay System

3.6.1 Conclusions

(C) The Grand View Relay System received television signals transmitted from a distance of 100 miles. These signals were successfully relayed 16 miles to the Ground Control Station with no degradation of picture quality. Command, telemetry and television signals were continuously relayed, without distortion or degradation, while the helicopter maneuvered at various altitudes up to a distance of 25 statute miles from the relay site. Severe interference on the command, telemetry and television signals caused the final series of extended range tests to be unsuccessful. The interference was caused by Atomic Energy Commission S-band radiation and by VHF signals radiated by a police radio transmitter installed at Angel Peak. No Grand View equipment problems were found during an exhaustive post test analysis.

(C) Multi-helicopter flights were not conducted. Equipment performance indicated that such flights could be supported.

3.6.2 Recommendations

(C) Additional engineering analysis of the system should be conducted to evaluate the susceptibility of the system to interferring signals. Additional flight testing should be completed to verify equipment performance.

(C) Verify the capability of the system to relay signals from more than one helicopter.

3.7 Egyptian Goose Radar System

3.7.1 Conclusions

(C) Evaluation of the results obtained from tests conducted at a range of 48 miles indicate that the system has the capability to detect a target the size of a 2 1/2 ton truck at a distance of 100 miles from the radar.

(C) Resolution tests conducted in the Egyptian Goose I configuration indicate that range and azimuth resolution performance specifications of the final radar configuration will be met.

(C) The scan converter displays developed for the radar operator and flight controllers provided excellent target acquisition and helicopter navigation information.

3.7.2 Recommendations

(C) Conduct elevated radar tests to validate maximum range detection and location performance.

(C) Conduct additional tests to establish the accuracy of ground truth tracking of helicopter reference to geographical coordinates.

4.0 NITE GAZELLE/MTI RADAR SYSTEM (U)

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ABSTRACT

(C) The NITE GAZELLE/MTI Radar System was tested at Nellis AFB, Nevada, from 7 through 21 May 1970. Thirty-five flight tests were conducted to determine the detection, location and identification capabilities of the system. In Nellis testing, the helicopter was remotely piloted to a specified area, the designated target was acquired by the radar, and identified by TV monitor. Vehicles were detected at an average range of 9.5 kilometers. Individuals were detected at a range of 7.5 kilometers and a group of three men were detected at a range of 8.5 kilometers. The radar system was able to provide target locations within an accuracy of 100 meters. Helicopter approach speeds to the targets varied from 10 to 40 knots and target speeds were maintained between 5 and 15 miles per hour.

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(U) NITE GAZELLE/MTI
Radar System in Launch Area (U)

Figure 1

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LIST OF ILLUSTRATIONS

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the AN/PPS-5 Moving Target Indicator Radar on the remotely piloted NITE GAZELLE helicopter. This sensor system is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems conceived to counter enemy infiltration along the roads and waterways of Southeast Asia. Sensors were selected to give the NITE GAZELLE helicopter a real time navigation, target acquisition and optical fire control capability under both day and low light level conditions of night. Weapon systems were selected to destroy a wide variety of fixed, hard and moving targets.

(C) The NITE GAZELLE/MTI Radar System consists of a modified AN/PPS-5 radar, mounted on the helicopter. A high resolution television system attached to the tracking mount provides navigation assistance and is used to perform a detailed investigation of target areas. Documentary film coverage is obtained from the 16 mm camera on the tracking mount. Flight and sensor controls are achieved by operators located in the ground control station.

(C) The Nellis test program demonstrated that the system met the design objectives of detecting a truck moving 10 miles per hour at a range of 10 kilometers. Tests were also conducted to determine the detection range of individuals and groups of men.

2.0 RESULTS

2.1 Summary of Results

(C) The NITE GAZELLE/MTI Radar demonstrated excellent detection and verification capabilities. The helicopter was remotely piloted to the designated test area where the radar searched for the targets. When the targets were acquired the flight controller used the radar information to fly the helicopter to intercept the targets. The flight continued under radar control until the targets were visible on the television monitor. Television information was then used to approach the targets close enough to make positive identification. During the data runs target positions were located within 100 meters of their true location. Results of the flight test program are summarized in Table 1.

TABLE 1 (Title Unclassified
Table Confidential)

SUMMARY OF TEST RESULTS

Target Type	Radar Detection Range (km)	TV Hand over Range (km)	Target Verified by (km)	Helicopter Approach speed (kts)
Vehicle	9.5	7.5	5.0	10 - 40
Three men with rifles	8.0	6.5	2.2	20 - 40
Three men w/o rifles	8.5	6.0	2.0	20 - 40
One man	7.5	2.5	1.0	20 - 40

2.2 Discussion of Test Results

(C) Thirty-five flight tests were conducted to demonstrate the detection and location capability of the NITE GAZELLE/MTI Radar System. Twenty-five flights were successful, five were partially successful and the desired results were not achieved on five flights. Five failures occurred early in the test program and were attributed to lack of personnel familiarization, equipment interference problems and the lack of precise operational procedures. A summary of all scheduled operations is shown in Appendix B. Appendix C presents test objectives, test plans and individual test results.

2.2.1 Vehicle Detection

(C) Vehicular detection tests were conducted with 1/4 and 3/4 ton trucks traveling around a circular path. Velocities varied from 5 to 15 miles per hour. Helicopter approach velocity was varied from 20 to 40 knots and test altitude was 1,000 feet or 2,000 feet. Maximum detection range was 10 kilometers. The minimum detection range was 7.5 kilometers, but this test

was conducted in an area with very poor background clutter. Since background clutter is required for proper operation of this radar, this range is not representative of the detection capability. Average detection range achieved on the good tests was 9.5 kilometers. The different target velocity, helicopter approach speeds and altitudes used during this program had no significant effect on the radar detection range of vehicles.

2.2.2 Personnel Detection

(C) Tests to determine the personnel detection capability of the radar were made with groups of people and individuals. On some tests the men were carrying rifles. Individuals, with and without rifles were detected at 7.5 kilometers. Groups of three men, with and without rifles, were detected at a range of 8.5 kilometers. Two groups of three men one with rifles and the other without rifles were detected at a range of 9.3 kilometers. Detection capability of all targets was equally good at airspeeds ranging from 20 to 40 knots. Helicopter altitude for all personnel detection tests was 2,000 feet. No significant detection differences were noted between the men with rifles versus those without rifles.

2.2.3 Helicopter and Target Location

(C) Helicopter location was determined by positioning the helicopter over a known reference marker and recording the position on the plotting board. These positions were then compared with survey data and the maximum deviation was 160 meters. Target locations were then measured and the maximum variation from their true position was determined to be 100 meters. Approximately 90 locations were completed.

2.2.4 Television Hand Over

(C) Television hand over procedures were developed. The helicopter was flown using radar information until the target was visible on the television monitor. Approach to the target was then continued until the target could be identified.

(C) Hand over on vehicular targets occurred at 7.5 kilometers. Groups of people were visible by 6.0 kilometers, but hand over on individuals did not occur until a helicopter-to-target range of 2.5 kilometers was reached.

(C) The television system performance was adequate to provide vehicle identification at a range of 5 kilometers, groups were identifiable at 2.0 kilometers and the one individual was identified from a range of 1.0 kilometer.

3.0 SYSTEM DESCRIPTION

(C) The AN/PPS-5 is a noncoherent pulse doppler radar system that has a maximum range of 10 kilometers and is capable of detecting targets moving at speeds from one to thirty miles per hour. The radar antenna has a horizontal beam width of 1.5 degrees and scans a 15 or 90 degree sector at a 9 degree per second rate. Vertical coverage is limited to -30 degrees from the horizontal plane of the helicopter axis. The system was modified for remote operation and installed on the NITE GAZELLE helicopter. In addition to the remote flight control equipment the helicopter was equipped with a high resolution TV system and a 16 mm camera. Information from the helicopter radar and TV systems was presented on appropriate displays located in the ground control station.

(U) The NITE GAZELLE/MTI Radar System is shown in Figure 2, and a detailed system description is presented in Appendix A.

(U) Close Up View of NITE GAZELLE/MTI Radar Installation (U)

Figure 2

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The main objectives of this test program were:

1. To determine the radar detection range of vehicles and people.
2. To determine the ability of the television system to identify people and vehicles.
3. To evaluate the ability of the navigation system to determine the location of targets and landmarks.
4. To develop procedures to hand over control from the radar to the television operator.

4.2 Test Plan

(C) Detection tests were conducted in the target nine area and at the one kilometer location. The Nellis test area is shown in Figures 3 and 4.

(C) The helicopter was remotely piloted to a designated area to start the data run. In general, data collection flights were started from a range of 10 kilometers from the specified target. Approach speeds, altitudes and target speeds were varied to evaluate detection ranges. All runs except three, were made on a direct approach to the target. The slant range from the helicopter to the target was recorded when the radar first detected the target, when the target was recognizable on the TV monitor and when control was transferred from the radar to TV operator. Target and landmark location data points were recorded and compared with survey data.

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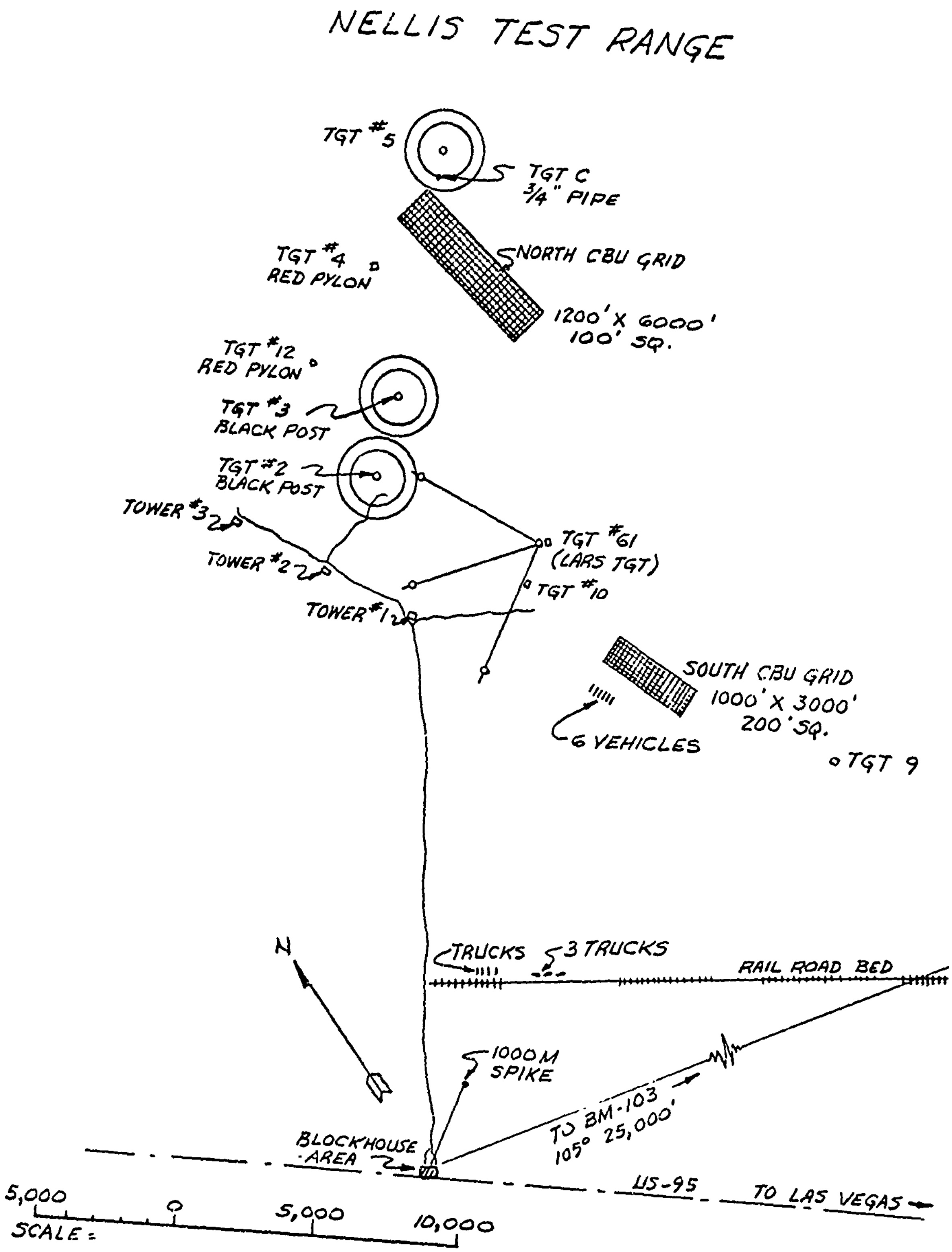

Figure 3

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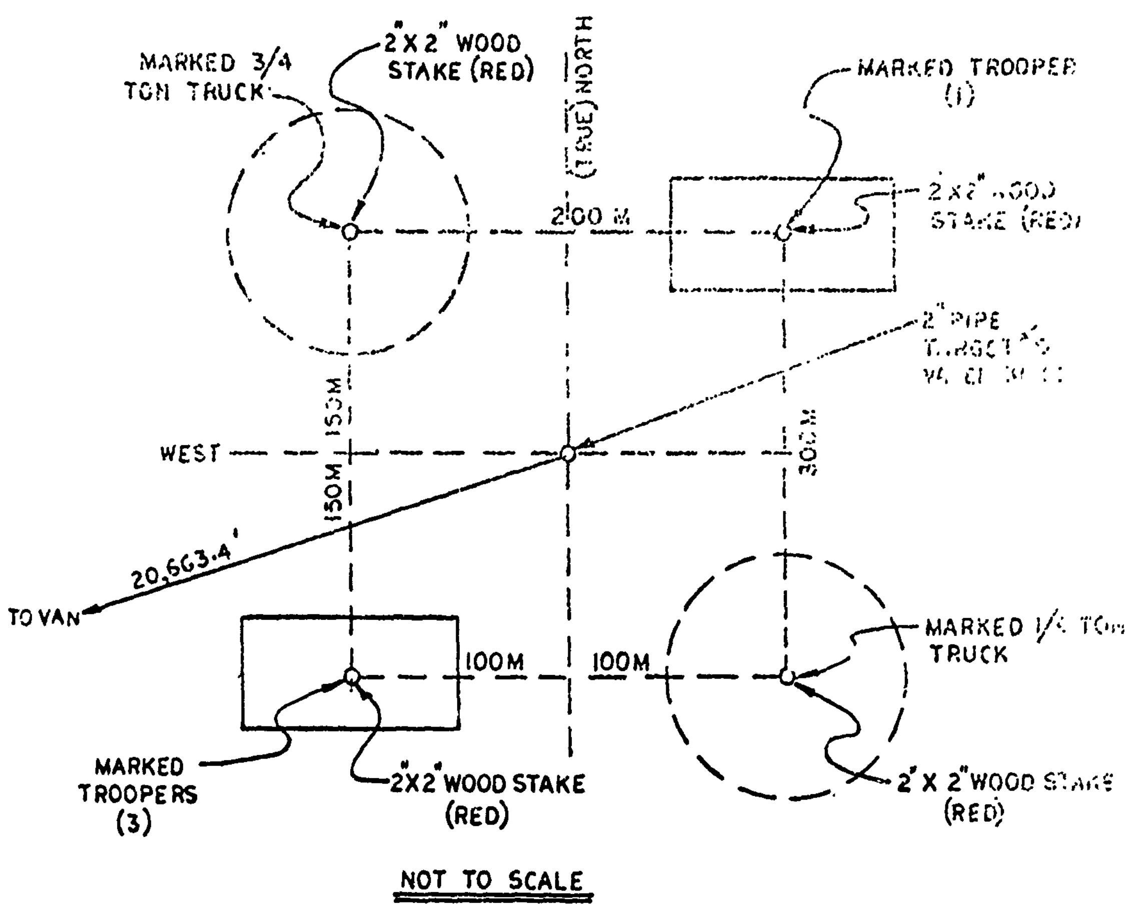

TARGET AREA 9

Figure 4

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5.0 CONCLUSIONS AND RECOMMENDATIONS

(C) This section discusses conclusions and recommendations in the following areas:

MTI Radar System
Helicopter
Data Link
Television
Tracking Mount
Ground Control Station

5.1 MTI Radar System

5.1.1 Conclusion

(C) The radar system performance equaled design expectations of vehicle detection at 10 kilometers. Personnel detection ranges exceeded the expected range of five kilometers.

5.1.2 Recommendation

(C) Improved antenna design and increased radar power would improve performance. Studies should be conducted to determine cost versus advantages of increasing the detection range of the radar and the detection probability when the helicopter is flying at speeds greater than 40 knots.

5.2 Helicopter

5.2.1 Conclusion

(U) The helicopter proved to be a reliable vehicle during the test program.

5.2.2 Recommendations

(U) None

5.3 Data Link

5.3.1 Conclusion

(U) The data link performance for helicopter and radar commands to the helicopter and response data from the helicopter and on board television system was adequate to meet all test objectives.

5.3.2 Recommendation

(U) None

5.4 Television

5.4.1 Conclusion

(C) The television system successfully identified all targets. Individuals were identified at a distance of one kilometer and trucks were identified at a five kilometer range. It was not suitable for night operations.

5.4.2 Recommendation

(U) The power and resolution of the lens system should be improved to increase the identification distances. A low light level television system should be used for night operations.

5.5 Tracking Mount

5.5.1 Conclusion

(U) The tracking mount performance satisfactorily positioned the television system for target identification. However, some difficulty was encountered when the radar operator attempted to transfer control to the TV operator because of the different location of the radar antenna and the television systems.

5.5.2 Recommendation

(U) The television system movement should be controlled by radar pointing information by a common mount or through servo driven controls. Since there was some indication of stability problems, the feasibility of using a common stabilized mount should be investigated.

5.6 Ground Control Station

5.6.1 Conclusions

(U) The ground control station satisfied all requirements. However, since this station was not designed for radar operation too much light was provided in the radar area.

(U) A fixed helicopter altitude was used to compute range to the target. Since the helicopter flew at other than 2,500 feet altitudes incorrect target ground ranges were developed.

5.6.2 Recommendations

(U) Interior arrangement of the ground control station should be optimized for the various operational areas.

(U) The capability to use actual helicopter altitude for range computations should be developed.

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GLOSSARY

ARPA	Advanced Research Projects Agency
A/C	Aircraft
C/I	Control Indicator
CRT	Cathode Ray Tube
DAME	Distance and Azimuth Measuring Equipment
MDS	Minimum Discernible Signal
MTI	Moving Target Indicator
PRF	Pulse Repetition Frequency

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(U) The NITE GAZELLE/MTI Radar System consists of a remotely piloted QH-50D helicopter with a modified AN/PPS-5 ground surveillance radar mounted on the front of the helicopter. A high resolution television camera attached to the tracking mount on the helicopter is used for navigation assistance and for detailed investigation of target areas. A 16 mm motion picture camera is attached to the tracking mount and is used to obtain documentary coverage of the targets. The system is shown in Figure A1.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE remotely piloted helicopter is a modified counter-rotating, double bladed helicopter, which was originally developed by the U. S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding an 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius of the NITE GAZELLE/MTI Radar System is 70 miles with 30 minutes on station.

2.2 The Surveillance Tracking Mount

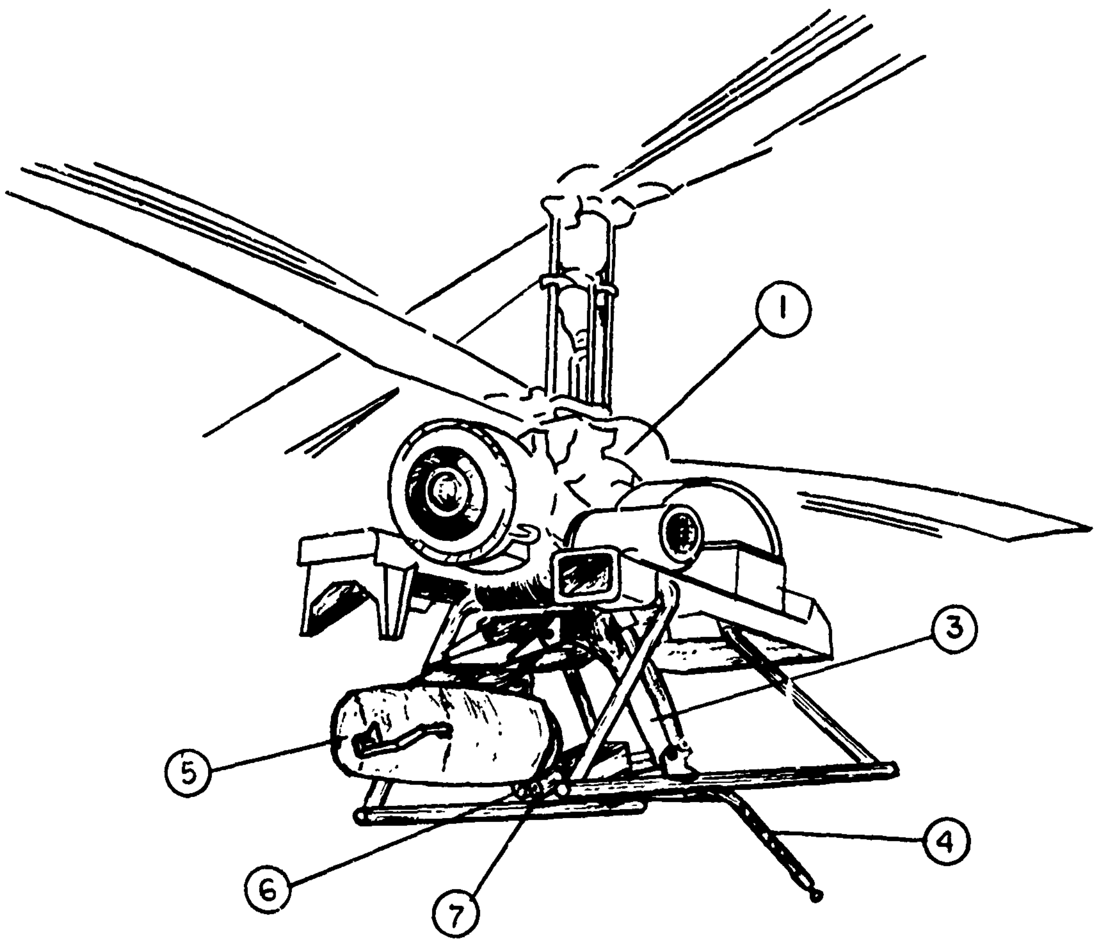
(U) The tracking mount is a rate commanded, gyro-stabilized sensor mount. The sensors are mounted on a platform suspended between the two arms of the mount. The mount insulates the sensors from most extraneous vibrations.

(U) The platform is remotely controlled in pan and tilt for accurate target tracking. The mount can be moved through a traverse angle of $\pm$ 25 degrees at a maximum pan rate of 10 degrees per second. The platform can be depressed from the horizontal to -100 degrees at a maximum tilt rate of 10 degrees per second.

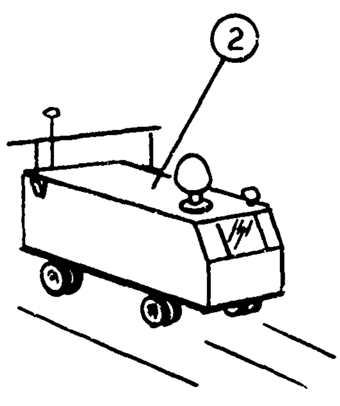
(U) The mount is centrally located under the drive shaft to provide maximum stability during in flight operations.

2.3 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and two observers' positions; one for the radar operator and the other for the TV operator.



NITE GAZELLE MTI RADAR SYSTEM



1. HELICOPTER DRONE QH-50D (UNFAIRED)
2. NITE GAZELLE CONTROL VAN
3. SURVEILLANCE TRACKING & WEAPON MOUNT
4. ANTENNA
5. PPS-5 ANTENNA
6. 16MM MOTION PICTURE CAMERA
7. DAY TELEVISION

Figure A-1

(U) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data and radio data are sent to the ground via an S-band link. TV imagery is transmitted to the ground via an L-band link.

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communications relay system, permits operations beyond the ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

(U) The radar operator monitors the helicopter position and operates the radar controls. The mount operator controls the mount position, the TV camera zoom lens, and the 16 mm film camera.

2.4 NITE GAZELLE/MTI Radar System

(C) The NITE GAZELLE/MTI Radar System consists of a modified AN/PPS-5 ground surveillance radar mounted on the front of the helicopter. The characteristics of the modified radar are summarized in Table A-1.

TABLE A-1 (Title Unclassified
Table Confidential)
MODIFIED AN/PPS-5 CHARACTERISTICS

Performance

Range	
Personnel	500 to 5,000 meters
Vehicles	500 to 10,000 meters
Minimum	500 meters
Resolution	100 meters
Accuracy	$\pm$ 50 meters
Azimuth Coverage	90 degrees
Elevation Coverage	-30 degrees from the horizon

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Table A-1 Continued

<u>Transmitting Subsystem</u>

Frequency	16.2 GHz
Wavelength	1.8 cm
Peak Power	2.2 kw
Average Power	4.4 watts
Pulse Repetition Rate	4,000 pps ± 5%
Pulse Width	0.5 microseconds
Duty Cycle	0.002

<u>RF Subsystem</u>

Reflector	Parabolic contour with elliptic outline (13.4" x 42")
Radiating Element	Buttonhook feed
Side Lobe Level	10 dB minimum
Back Lobe Level	10 dB minimum
Polarization	Horizontal
Horizontal Beam Width	1.5 degrees
Vertical Beam Width	3.5 degrees
Scan Speed Automatic	9 degrees/second
Duplexer	Ferrite circulator/solid state limiter

<u>Receiving Subsystem</u>

Type	Heterodyne, single conversion
Frequency	16.25 GHz (tunable ± 50 MHz)
Bandwidth	1.5 MHz
Sensitivity	-99 dBm, MDS
Audio Bandwidth	50-1700 Hz
Overall Noise Figure	14 dB
Intermediate Frequency	60 MHz

<u>Sychronizing Subsystem</u>

PRF Generator	6 Volt inverter in the power supply
System Trigger	Derived from the radar modulator

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Table A-1 Continued

B Scope Display

Presentation	Intensity-modulated display
Cathode-ray Tube (CRT)	SC3364-P7
Sweep Length	10,000 Meters
Range Marker	Intensified range gate
Azimuth Scan	$\pm$ 45 degrees corresponds to full CRT width

A Scope Display

Presentation	Deflection-modulated display
Cathode-ray Tube (CRT)	3 BGP-1
Sweep Length	10,000 Meters
Range Marker	Intensified range gate
Display Video	MTI or normal
MTI System	Range gated filters - 100 meter resolution

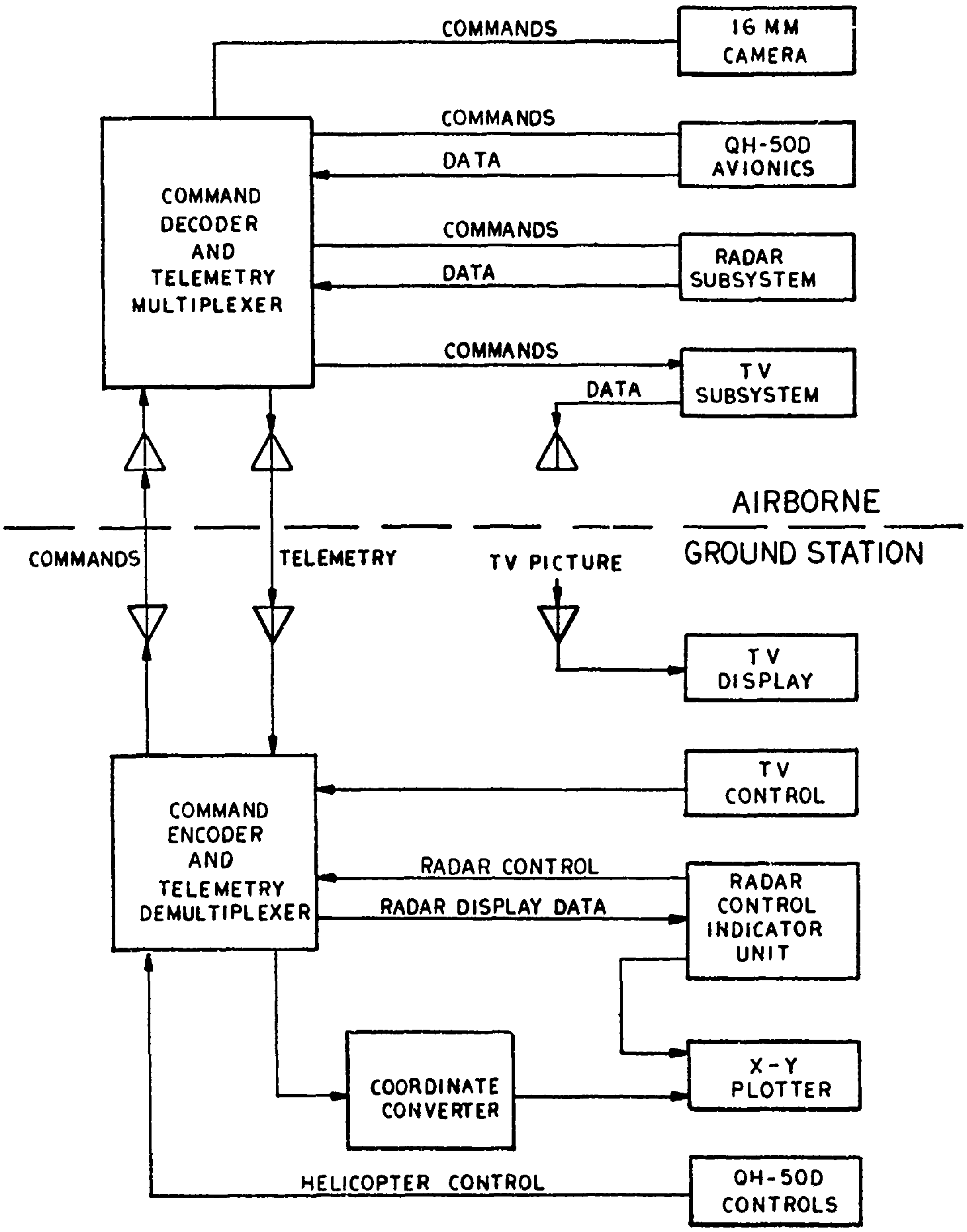
Auxiliary B Display

H P 1300 A	X-Y display slaved to C/IB scope display

Plotting Board

X-Y Recorder	H P 7005B
Display Area	11" x 17"
Scale Factor A	50,000:1
Scale Factor B	100,000:1
Display Functions	Helicopter & target positions
Coordinate Conversion	Sin/Cos servo type

(C) The NITE GAZELLE system is flown, by remote control, to the start point of the surveillance mission with the radar in the wide sector scan mode. In this mode, the radar automatically scans a plus and minus 45 degree section at a scan rate of 9 degrees per second. On station the helicopter hovers to perform wide area surveillance with the radar still in the wide sector scan mode. Local terrain will be the deciding factor in helicopter altitude, but in general, the highest possible altitude will be selected. A full 360 degree scan can be completed in six minutes by rotating the helicopter 90 degrees after the completion of nine scans on one heading. When movement is detected, the radar is switched to the narrow ($\pm$ 7.5 degrees) scan mode and the helicopter approaches the suspect area at an altitude and speed consistent with operational requirements. At a range of 5 km, it is possible to identify the type of vehicular targets under surveillance. When deemed



SYSTEM BLOCK DIAGRAM

Figure A-2

necessary, a closer approach is made and a detailed examination of the targets is performed by the TV system. When desired, a photographic record of the area is made for detailed analysis at a later time. A system block diagram is shown in Figure A-2.

(C) Target ranging is accomplished in the Radar Signal Processor. The radar controller initiates commands that position a range marker over the target as displayed in the Control/Indicator. The target range can then be read from counters or plotted on the X-Y plotter. Target azimuth is determined by processing the commanded drone heading, the heading error signal and the angular position of the radar antenna. These two functions provide the operator with target position. Helicopter position is also available from the Distance and Azimuth Measuring Equipment. Since only one of these functions can be displayed, the operator selects the one that satisfies his requirement.

2.5 Day Television System

(U) The Day Television System is used to visually identify the targets acquired by the NITE GAZELLE/MTI Radar Sensor System. The camera unit is manufactured by COHU Electronics Corporation. This cylindrical camera unit is 4 inches in diameter, 19 inches long and weighs 11 pounds. Resolution is 945 lines at one footcandle illumination on the face plate. The camera control unit weighs 15 pounds.

(U) The camera lens is a 15 mm to 150 mm zoom with a 2X extender, changing focal length and zoom to 30 to 300 mm, f5.6 to f22, covering a field of view of 23 degrees down to 2.3 degrees at full zoom. The zoom and f-stop are remotely controlled from the ground station. A projected reticle with remotely controlled intensity is also provided. The TV transmission requires a bandwidth of 14.8 MHz and has a power requirement of 45 watts.

2.6 16 mm Motion Picture Camera

(U) The 16 mm Motion Picture Camera is co-mounted beside the TV camera. A filmed record of the mission is obtained for post-flight evaluation.

(U) The camera is manufactured by Photosonics and operates at a frame rate of 24 to 200 frames per second. It is fitted with a 25 to 250 mm zoom lens with a normal aperture of f2.8 - 22. The focal length is remotely controlled in flight to maintain proper magnification and field of view to document the mission. The on board exposure control unit is automatic.

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APPENDIX B

SCHEDULED OPERATIONS (U)

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR MTI RADAR

Date	Test No.	Plan	Comments
5/7/70	50	Initial Checkout	The first run was cancelled because of an A/C control problem. A telemetry problem occurred on the second run.
5 8 70	50	Checkout flight using a simulator	The simulator was not detected because of the flight altitude.
5/8/70	50	Detect one 3/4 ton truck and one man	Numerous aircraft heading changes made the radar data unusable.
5/8/70	50	Detect one 3/4 ton truck and one man	The truck was observed on TV, but range gate problems prevented radar acquisition on run 4. On run 5, the truck was acquired at 9.5 km.
5/11/70	51	Detect one 3/4 and one 1/4 ton truck	Signal acquired at 7.5 km.
5/11/70	50	Detect one truck and one man	No acquisition because of a radar problem.
5/13/70	50	Detect the doppler simulator	Signal acquired at 9.8 km.
5/14/70	50	Detect a 3/4 ton truck	No radar data because of poor clutter.
5/15/70	54	Detect two vehicles	Truck acquired at 9.0 km.
5/15/70	55	Detect two groups of three men	Signal acquired at 9.3 km.

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Table B-1 Continued

Date	Test No.	Plan	Comments
5/15/70	56	Detect the doppler simulator	Not detected because of aircraft altitude.
5/15/70	57	Acquire location data	Seven points acquired.
5/15/70	56	Detect men with and without rifles	Signal acquired at 9.5 km.
5/15/70	50	Detect one man and one truck	Truck acquired at 9.5 km.
5/15/70	50	Detect one man and one truck	Signal acquired at 8.0 km.
5/15/70	56	Detect AVCO Beacon	Signal acquired at 2.5 km.
5/18/70	50	Detect one man and one truck	Signal acquired at 9.0 km.
5/18/70	55	Detect three men with rifles	Signal acquired at 8.0 km.
5/18/70	55	Detect three men without rifles	Signal acquired at 8.5 km.
5/19/70	56	Detect one man	Signal acquired at 7.5 km.
5/19/70	56	Detect one man	Signal acquired at 5.2 km.
5/19/70	58	Detect TRIDIA Beacon	Range radar interference prevented acquisition.
5/19/70	58	Detect TRIDIA Beacon	Signal acquired at 2.5 km.
5/19/70	58	Detect TRIDIA Beacon	Signal acquired at 2.5 km.
5/20/70	59	Hand Over Test	Hand Over at 2.3 km
5/20/70	59	Hand Over Test	Hand Over at 2.0 km
5/20/70	59	Hand Over Test	Hand Over at 1.8 km
5/20/70	59	Hand Over Test	Hand Over at 2.0 km

Table B-1 Continued

Date	Test No.	Plan	Comments
5/20/70	59	Detect a simulator at a 40° approach angle	Unsuccessful
5/20/70	59	Detect a simulator at a 40° approach angle	Unsuccessful
5/20/70	59	Detect a simulator at a 40° approach angle	Unsuccessful
5/20/70	59	Determine target location	Four measurements agree within 100 meters.
5/21/70	59	Hand over and photograph	Hand over at 2.0 km
5/21/70	59	Hand over and photograph	Hand over at 1.8 km
5/21/70	59	Hand over and photograph	Hand over at 1.8 km

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APPENDIX C

FLIGHT TEST DATA FOR MTI RADAR

(C) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

INITIAL CHECK OUT
Flight No. 1 Test No. 50
7 May 1970

(C) This test was the initial flight scheduled to verify the operational aspects of the system, to operate all recording devices and to detect a 3/4 ton truck moving at 10 mph and one man walking. The helicopter lifted off at 1212 and the data run started at 1241. Flight altitude was 2000 feet and ground speed was 12 knots. The location of the target with respect to the helicopter was difficult to determine because of errors in the plotting board chart used for navigation. The error was corrected after the flight. The PPS-5 radar video was not satisfactory because of a low telemetry signal level. Video photographs were not satisfactory because the helicopter heading was changing when they were being made. Adjustments of the telemetry system after the flight eliminated the video problem and better coordination between the flight controller and the radar operator eliminated the video photography problem. Flight time was seventy-eight minutes.

<u>Weather Conditions</u>

Barometric pressure: 26.65'' Hg
Temperature: 72° F

Wind, Surface:	5 knots from 280° T
500'	10 knots from 270° T
1000'	12 knots from 280° T
1500'	13 knots from 280° T
2000'	15 knots from 300° T

INITIAL CHECK OUT
Flight No. 2 Test No. 50
8 May 1970

(C) This test was scheduled to continue the flights to verify the operational aspects of the system, to operate all recording devices, and to detect a target simulator located 6 kilometers from the launch pad. One flight was made at an altitude of 600 feet and another was completed at 1,500 feet. No signal was observed. Radar sensitivity adjustments were made and the simulator was moved closer to the launch pad. A check of all systems was made prior to the next lift-off. All systems performed satisfactorily and a flight

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from an altitude of 130 feet was completed. The simulator was not observed because the altitude of the helicopter placed it out of the radar antenna field of view. Flight time was twenty-six minutes.

Weather Conditions

Barometric pressure: 26.68" Hg
Temperature: 75° F
Wind, Surface: 3 knots at 330° T

TARGET DETECTION
Flight No. 3 Test No. 50
8 May 1970

(C) This test was scheduled to continue the flights to verify the operational aspects of the system, to operate all recording devices and to detect a 3/4 ton truck, moving at 10 mph, and one man. The flight altitude was 1000 feet and the ground speed was 10 knots. The radar data acquired during the flight were unusable because of numerous heading changes made during the approach to the target. Coordination procedures were developed after the flight. The TV system was used to identify the man at a range of 2,000 yards. Flight time was sixty-two minutes.

Weather Conditions

Barometric pressure: 26.68" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 300° T

TARGET DETECTION
Flight No. 4 Test No. 50
8 May 1970

(C) This test was conducted to continue the flights to detect a 3/4 ton truck moving at 10 mph and one man walking. During the approach to the target area on the first pass, the ground speed was 26 knots and the altitude was 2,000 feet. The truck was observed on the TV monitor at a slant range of 5.6 kilometers. Range gate problems prevented radar acquisition. The single man was observed on TV at a range of 0.7 kilometers. For the second pass, the ground speed was increased to 34 knots. The truck was detected at a range of 9.5 kilometers. Fifteen data points for target locations were obtained during these two runs. Total flight time was fifty-nine minutes.

Weather Conditions

Barometric pressure: 26.62" Hg
Temperature: 80° F
Wind, Surface: 15 knots from 330° T

TARGET DETECTION
Flight No. 5 Test No. 51
11 May 1970

(C) This test was conducted to determine the detection range of a 3/4 ton truck moving at 5 mph and a 1/4 ton truck moving at 15 mph. Flight altitude was 1000 feet and ground speed was 30 knots. The radar acquired signal at 7.5 kilometers and the two targets were resolved at a range of 6.0 kilometers. The trucks were visible on TV at a range of over 10 kilometers. Six location data points were acquired during this run. Flight time was seventy-three minutes.

Weather Conditions

Not Available

TARGET DETECTION
Flight No. 6 Test No. 50
11 May 1970

(C) This test was scheduled to determine the radar detection range of a 3/4 ton truck moving at 10 mph and of one man. Prior to this flight the radar antenna depression angle was changed from -2° to -4° . During the flight ground clutter appeared to be abnormal. After the flight it was determined that a problem existed in the radar actuator and another lift-off was performed to verify the type of problem. A bent actuator pin was determined to be the cause of this failure. Repairs required one and one-half hours. No data were obtained on this run because of this problem. Flight time was sixty-three minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 68° F
Wind, Surface: 6 knots from 300° T

TARGET DETECTION
Flight No. 7 Test No. 50
13 May 1970

(C) This test was conducted to determine the detection range of the doppler simulator. A DME problem was discovered after lift-off and the helicopter was returned to the pad. The problem was traced to a bad connection to the plotting board in the control van. After the system was repaired the helicopter lifted off to continue the flight. The data run was started at 10 kilometers from the target, airspeed was 18 knots and altitude was 425 feet. Radar acquisition occurred at 9.8 kilometers and verification was made at 8.5 kilometers. Mount control was lost shortly after take-off. A blown fuse was replaced after the flight and the system performance was declared to be satisfactory. A data run was made at an altitude of 2000 feet and thirteen data points were obtained. Flight time was forty-eight minutes.

Weather Conditions

Barometric pressure: 26.67" Hg
Temperature: 75° F

Wind, Surface:	7 knots from 270° T
500'	12 knots from 320° T
1000'	12 knots from 320° T
1500'	12 knots from 320° T
2000'	12 knots from 320° T

TARGET DETECTION
Flight No. 8 Test No. 50
14 May 1970

(C) This test was conducted to determine the detection range of the doppler simulator and a 3/4 ton truck moving at 10 mph. Lift-off occurred at 0821 and one pass was acquired at a range of 10 kilometers and tracked to a range of 8.5 kilometers. On the second run the truck was not acquired because there was no background clutter. The flight was conducted at an altitude of 2,000 feet and a ground speed of 40 kr [illegible]. After touch down the vertical gyro failed and was replaced. The time required for the replacement caused the next scheduled run to be cancelled. Flight time was seventy-six minutes.

Weather Conditions

Barometric pressure: 26.88" Hg
Temperature: 66° F

Wind, Surface:	15 knots from 360° T
1000'	27 knots from 360° T
2000'	25 knots from 362° T
3000'	21 knots from 362° T

TARGET DETECTION
Flight No. 9 Test No. 54
15 May 1970

(C) This test was conducted to determine the detection range of two vehicles, and to practice TV hand over techniques. One vehicle was a 3/4 ton truck moving at 10 mph and the other was a 1/4 ton truck moving at 10 mph. Altitude was 2,000 feet and a 20 knot ground speed was used. The trucks were acquired at a range of 9.0 kilometers. Seven location data points were obtained. The first TV hand over occurred at 6.5 kilometers and the second was completed at 3.0 kilometers. Flight time was forty minutes.

Weather Conditions

Barometric pressure: 26.56" Hg
Temperature: 76° F
Wind, Surface: 7 knots from 240° T

TARGET DETECTION
Flight No. 10 Test No. 55
15 May 1970

(C) This test was conducted to determine the detection range of two groups of men, and to practice TV hand over techniques. One group consisted of three men with rifles and the other group did not have weapons. Flight altitude was 2,000 feet and the ground speed was 20 knots. The targets were acquired at 9.3 kilometers and TV hand over occurred at 7.5 kilometers. Another TV hand over was completed at 4.0 kilometers. Nine location data points were recorded. Flight time was fifteen minutes.

Weather Conditions

Barometric pressure: 26.56" Hg
Temperature: 76° F
Wind, Surface: 7 knots from 240° T

TARGET DETECTION
Flight No. 11 Test No. 56
15 May 1970

(C) This test was conducted to determine the detection range of the doppler simulator. Flight altitude was 1,000 feet and the ground speed was 40 knots. The target was not detected because the helicopter was too high and too close to the target. Flight time was fifteen minutes.

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Weather Conditions

Barometric pressure: 26.56" Hg
Temperature: 76° F
Wind, Surface: 7 knots from 240° T

TARGET LOCATION
Flight No. 12 Test No. 57
15 May 1970

(C) This test was conducted to acquire location data while the aircraft was flying toward the doppler simulator. TV hand over practice was also scheduled. Flight altitude was 2,000 feet and the ground speed was 27 knots. The simulator was acquired at a range of 1[illegible] kilometers. Seven location data points were acquired and location difference varied from +150 to -300 meters. TV handover was completed at a range of 3.0 kilometers. Flight time was nine minutes.

Weather Conditions

Barometric pressure: 26.55" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 290° T

TARGET DETECTION
Flight No. 13 Test No. 56
15 May 1970

(C) This test was conducted to determine the detection range of two men and to practice TV hand over One man had a rifle and the other did not. Flight altitude was 2,000 feet and the ground speed was 27 knots. Radar signals were acquired at 9.5 kilometers and the two individuals were identified at 9.2 kilometers. TV hand overs were completed at 7.0 and 2.5 kilometers. Eight location data points were obtained. Locations averaged +100 meters. Flight time was twenty-four minutes.

Weather Conditions

Barometric pressure: 26.55" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 290° T

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TARGET DETECTION
Flight No. 14 Test No. 50
15 May 1970

(C) This test was conducted to determine the detection range of a 3/4 ton truck moving at 10 mph and one man walking. TV hand over practice was also scheduled. The flight altitude was 1,000 feet and the ground speed was 27 knots. The truck target was acquired at a range of 9.5 kilometers. It was difficult to distinguish the man. Eight location data points were recorded. TV hand over was completed at a range of 3.2 kilometers. Flight time was nine minutes.

Weather Conditions

Barometric pressure: 26.55" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 290° T

TARGET DETECTION
Flight No. 15 Test No. 50
15 May 1970

(C) This test was conducted to determine the detection range of a 3/4 ton truck moving at 10 mph and one man walking. TV hand over was also scheduled. The flight altitude was 1,000 feet and the ground speed was 40 knots. The targets were acquired at a range of 8.0 kilometers when the targets started to move. Nine location data points were obtained. TV hand over was completed at a range of 3.5 kilometers. Flight time was twenty-five minutes.

Weather Conditions

Barometric pressure: 26.55" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 290° T

BEACON DETECTION
Flight No. 16 Test No. 56
15 May 1970

(C) This test was scheduled to determine the detection range of the AVCO beacon. The flight altitude was 400 feet and the ground speed was 27 knots. The signal was acquired at a range of 2.5 kilometers. The signal was lost after a very short period of track when the helicopter changed heading to make a landing approach. Flight time was nine minutes.

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Weather Conditions

Barometric pressure: 26.55" Hg
Temperature: 80° F
Wind, Surface: 10 knots from 290° T

TARGET DETECTION
Flight No. 17 Test No. 50
18 May 1970

(C) This test was conducted to determine the detection range of a 3/4 ton truck moving at 10 mph and one man walking. TV hand over was also scheduled. Flight altitude was 2,000 feet and the ground speed was 10 knots. Radar signal was acquired at 9.0 kilometers and both targets were identified. TV hand over occurred at 7.5 and 2.0 kilometers. Eight location data points were acquired. Flight time was twenty-six minutes.

Weather Conditions

Barometric pressure: 26.64" Hg
Temperature: 77° F

Wind, Surface:	3 knots from 100° T
500'	5 knots from 100° T
1000'	7 knots from 090° T
2000'	6 knots from 130° T

TARGET DETECTION
Flight No. 18 Test No. 55
18 May 1970

(C) This test was conducted to determine the detection range of three men with rifles and to practice TV hand over techniques. Flight altitude was 2,000 feet and the ground speed was 40 knots. Signal from the target was acquired at 8.0 kilometers and individual movements were easy to identify. TV hand over was completed at a range of 2.5 kilometers. Five location data points were recorded. Flight time was eleven minutes.

Weather Conditions

Barometric pressure: 26.64" Hg
Temperature: 77° F

Wind, Surface:	3 knots from 100° T
500'	5 knots from 100° T
1000'	7 knots from 090° T
2000'	6 knots from 130° T

TARGET DETECTION
Flight No. 19 Test No. 55
18 May 1970

(C) This test was conducted to determine the detection range of three men without rifles and to practice TV hand over techniques. Flight altitude was 2, 000 feet and the ground speed was 40 knots. Signal from the target was acquired at a range of 8.5 kilometers. TV hand over occurred at a range of 2.5 kilometers. At the end of the run the radar antenna locked in the extreme left position. After the flight a loose roll pin was reinstalled in the proper position and this action corrected the problem. Flight time was twenty-one minutes.

Weather Conditions

Barometric pressure: 26.44" Hg
Temperature: 77° F
Wind, Surface: 3 knots from 100° T
500' 5 knots from 100° T
1000' 7 knots from 090° T
2000' 6 knots from 130° T

TARGET DETECTION
Flight No 20 Test No. 56
19 May 1970

(C) This test was conducted to determine the detection range of one man and to practice TV hand over techniques. Flight altitude was 2, 000 feet and the ground speed was 20 knots. The radar acquired signal at 7.5 kilometers. Eleven location data points were acquired. No TV hand over was accomplished because the man could not be distinguished from the background. Flight time was twenty-eight minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 80° F
Wind, Surface: 5 knots from 040° T

TARGET DETECTION
Flight No. 21 Test No. 56
19 May 1970

(C) This test was conducted to determine the detection range of one man and to practice TV hand over techniques. Flight altitude was 2, 000 feet and

ground speed was 20 knots. The man did not start moving until the helicopter was at a range of 5.2 kilometers. Signal was acquired when he started to move. Four location data points were obtained. No TV hand over was attempted because the man could not be distinguished from the background. Flight time was fifteen minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 80° F
Wind, Surface: 5 knots from 040° T

BEACON DETECTION
Flight No. 22 Test No. 58
19 May 1970

(C) This test was conducted to determine the detection range of a TRIDIA beacon. Flight altitude was 1,000 feet and ground speed was 30 knots. The Nellis range radars interrogated the TRIDIA beacon and made the display unusable. Flight time was sixteen minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 80° F
Wind, Surface: 5 knots from 040° T

BEACON DETECTION
Flight No. 23 Test No. 58
19 May 1970

(C) This test was conducted to determine the detection range of a TRIDIA beacon. Flight altitude was 500 feet and the ground speed was 40 knots. Range radars interrogated the beacon. When they were turned off the PPS-5 Radar acquired the TRIDIA beacon at a range of 2.5 kilometers. Flight time was eleven minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 80° F
Wind, Surface: 5 knots from 040° T

BEACON DETECTION
Flight No. 24 Test No. 58
19 May 1970

(C) This test was conducted to determine the detection range of the TRIDIA beacon. Flight altitude was 500 feet and ground speed was 40 knots. The range radars were secured prior to this run. The run started at 4.0 kilometers and the TRIDIA signal was acquired at 2.5 kilometers. Flight time was nine minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 80° F
Wind, Surface: 5 knots from 040° T

SPECIAL HAND OVER
Flight No. 25 Test No. 59
20 May 1970

(C) This test was conducted as a special hand over test using a 3/4 ton truck, moving at 10 mph as a target. The run started at a range of 4.0 kilometers and the hand over was completed at 2.3 kilometers. Flight altitude was 1,000 feet and ground speed was 20 knots. Flight time was sixteen minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 74° F

Wind, Surface:	1 knot from 060°	T
500'	16 knots from 290°	T
1000'	21 knots from 280°	T
2000'	23 knots from 280°	T

SPECIAL HAND OVER
Flight No. 26 Test No. 59
20 May 1970

(C) This test was conducted as a special hand over test using three men as a target. Flight altitude was 1,000 feet and the ground speed was 20 knots. The run started at a range of 4.0 kilometers. Radar signal was acquired immediately and the hand over was completed at 2.0 kilometers. Flight time was ten minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 290° T
1000' 21 knots from 280° T
2000' 23 knots from 280° T

SPECIAL HAND OVER
Flight No. 27 Test No. 59
20 May 1970

(C) This test was conducted as a special hand over test using one man, wearing a dark shirt, as a target. Flight altitude was 1,000 feet and the ground speed was 20 knots. The run was started at a range of 4.0 kilometers. Radar acquisition occurred at the beginning of the run and the hand over was completed at a range of 1.8 kilometers. Flight time was eight minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 290° T
1000' 21 knots from 280° T
2000' 23 knots from 280° T

SPECIAL HAND OVER
Flight No. 28 Test No. 59
20 May 1970

(C) This test was conducted as a special hand over test using one man wearing a dark shirt and dark trousers. Flight altitude was 1,000 feet and the ground speed was 20 knots. The radar acquired signal when the run started at 4.0 kilometers. The hand over was completed at 2.0 kilometers. Flight time was nine minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 280° T
1000' 21 knots from 280° T
2000' 23 knots from 290° T

OFFSET BEACON DETECTION
Flight No. 29 Test No. 59
20 May 1970

(C) This test was conducted to determine the ability of the system to detect the target simulator when the helicopter approaches the target area from an angle of 40° . The flight altitude was 1,000 feet, ground speed was 20 knots, and the approach was made crossing the flight line from right to left. Some intermittent signals were observed but solid track was not achieved. Very little data were expected because of the limited scan rate of the radar antenna. Flight time was twelve minutes.

Weather Conditions

Barometric pressure: 26.54" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 280° T
1000' 21 knots from 280° T
2000' 23 knots from 290° T

OFFSET BEACON DETECTION
Flight No. 30 Test No. 59
20 May 1970

(C) This test was conducted to determine the ability of the system to detect the doppler simulator when the helicopter approaches the target from an offset angle of 40° . The flight altitude was 1,000 feet, ground speed was 20 knots, and the flight line crossing was made from left to right. Some intermittent signals were observed but continuous track was not maintained. Very little data were expected because of the limited scan rate of the radar antenna. Flight time was eleven minutes.

Weather Conditions

Barometric pressure: 26.54" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 280° T
1000' 21 knots from 280° T
2000' 23 knots from 290° T

OFFSET BEACON DETECTION
Flight No. 31 Test No. 59
20 May 1970

(C) This test was conducted to determine the ability of the system to detect the doppler simulator when the helicopter approaches the target from an offset angle of 25°. The flight altitude was 1,000 feet, the ground speed was 40 knots and the flight line crossing was made from right to left. Some intermittent signals were observed but continuous track was not maintained. Very little data were expected because of the limited scan rate of the radar antenna. Flight time was five minutes.

Weather Conditions

Barometric pressure: 26.54" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 280° T
1000' 21 knots from 280° T
2000' 23 knots from 290° T

SPECIAL HAND OVER
Flight No. 32 Test No. 59
20 May 1970

(C) This test was conducted to determine the ability of the system to hover over a known location and measure the distance to the target. Flight altitude was 1,000 feet. Four location points were measured and the distances agreed within 100 meters. Flight time was twenty-one minutes.

Weather Conditions

Barometric pressure: 26.54" Hg
Temperature: 74° F
Wind, Surface: 1 knot from 060° T
500' 16 knots from 280° T
1000' 21 knots from 280° T
2000' 23 knots from 290° T

SPECIAL HAND OVER
Flight No. 33 Test No. 59
21 May 1970

(C) This test was a special TV hand over and photographic test using a 3/4 ton truck moving at 10 mph as a target. Flight altitude was 1,000 feet

and the ground speed was 40 knots. The run started at 4.0 kilometers from the target and hand over was completed at 2.0 kilometers. Flight time was fifteen minutes.

Weather Conditions

Barometric pressure: 26.70" Hg
Temperature: 76° F
Wind, Surface: 6 knots from 0° T

SPECIAL HAND OVER
Flight No. 34 Test No. 59
21 May 1970

(C) This test was a special TV hand over and photographic test using three men as a target. Flight altitude was 1,000 feet and ground speed was 40 knots. The run started at 4.0 kilometers and hand over was completed at 1.8 kilometers. Flight time was nine minutes.

Weather Conditions

Barometric pressure: 26.70" Hg
Temperature: 76° F
Wind, Surface: 6 knots from 0° T

SPECIAL HAND OVER
Flight No. 35 Test No. 59
21 May 1970

(C) This test was a special TV hand over and photographic test using one man as a target. Flight altitude was 1,000 feet and the ground speed was 40 knots. The run started at 4.0 kilometers and the hand over was completed at 1.8 kilometers. Flight time was thirteen minutes.

Weather Conditions

Barometric pressure: 26.70" Hg
Temperature: 76° F
Wind, Surface: 6 knots from 0° T

6.0 NITE GAZELLE/LASER AIDED ROCKET SYSTEM (U)

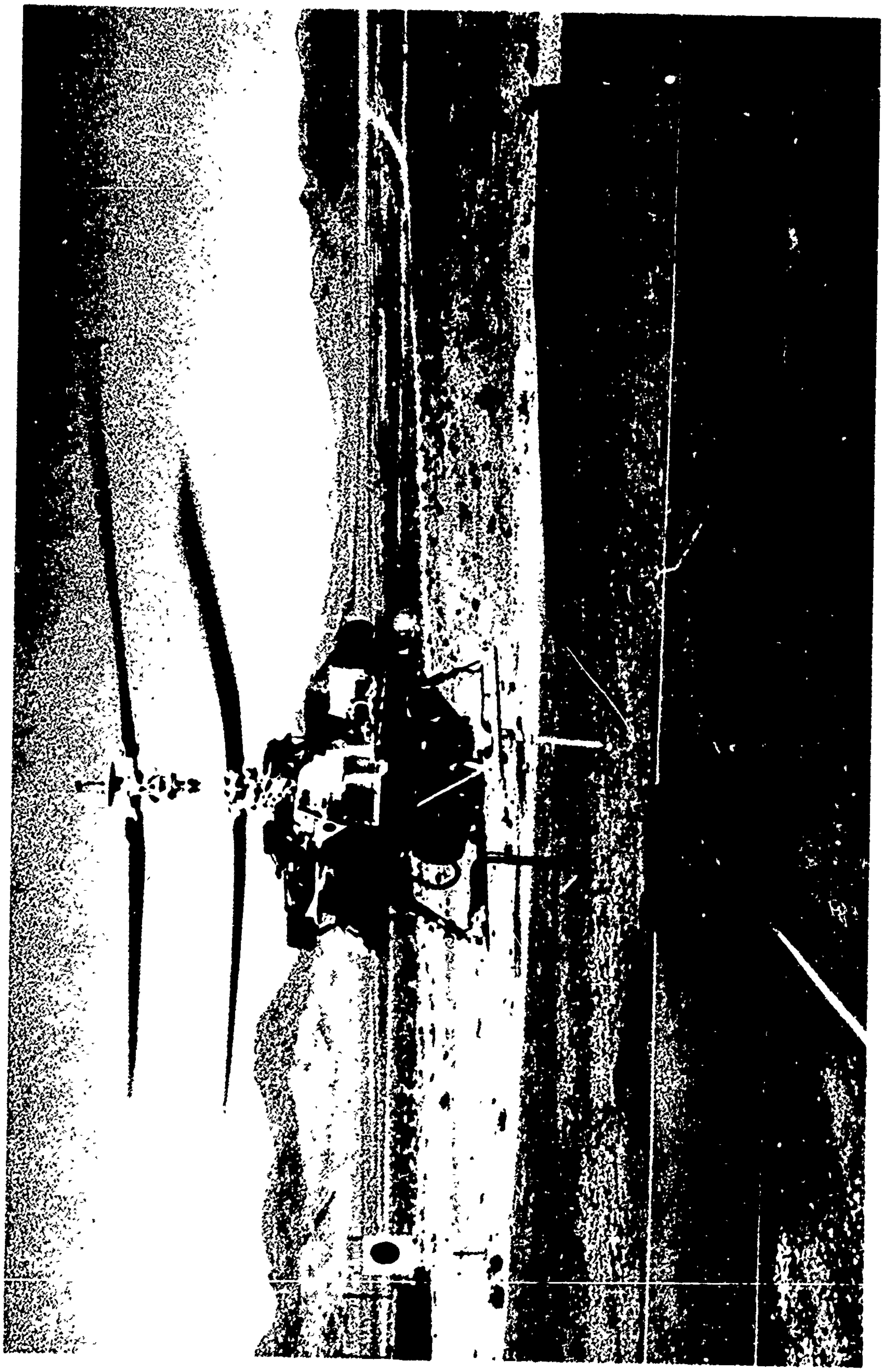
ABSTRACT

(C) The NITE GAZELLE/Laser Aided Rocket System (LARS) was tested at Nellis AFB, Nevada, from 11 March 1970 through 2 February 1972. Seventeen guided and twenty-seven unguided missiles were launched to determine miss distance, helicopter, launcher, tracker and mount performance. Missiles were launched at target ranges of 4800 to 8100 feet. Targets varied from plywood bull's-eye to stationary and moving two and one half ton trucks and tanks. Minimum acceptable launch range was determined to be 5200 feet. Other tests were conducted to obtain signal strength and pointing accuracy data and to evaluate subsystem improvements. The test program consisted of three phases: LARS I, LARS II (Day) and LARS II (Night).

(C) The LARS I phase demonstrated the Proportional Lead Guidance concept by impacting a missile only one foot from the center of the target when launched at a range of 4800 feet from the target. The laser target illuminator used during this test phase was located on the ground approximately 500 feet in front of the target.

(C) For the LARS II, both day and night, the laser illuminator was located on the tracking mount for all except four tests. Mount improvements were made that changed the tracking accuracy from over 1.0 milliradian to $\pm$ 0.2 milliradian. Best performance for a day LARS II using the airborne illuminator was a direct hit on the laser spot held at the desired impact point on a stationary tank. This launch occurred at a target range of 6200 feet.

(C) Unguided missiles launched at night demonstrated that the Low Light Level Television System and the contrast tracker could maintain the laser spot on the desired impact point. However, the two guided LARS II night launches were unsuccessful. Unexpected missile debris caused the tracker to lose lock and the laser spot drifted away from the target on the first launch. On the second launch the contrast tracker lost lock because a bright spot appeared in the track gate. When the TV inhibit cycle was completed and the operator observed that the mount was not tracking the target, an attempt was made to position the spot on the target. The remaining flight time was too short and the missile missed the target.



NITE GAZELLE/LARS
Weapon System in Flight

Figure 1

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the Laser Aided Rocket System (LARS) on the remotely piloted NITE GAZELLE helicopter. This weapon system is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensors Systems conceived to counter enemy infiltration along the roads and waterways of Southeast Asia. Sensors were selected to give the NITE GAZELLE helicopter a real time navigation, target acquisition and optical fire control capability under both day and low light level conditions of night. Weapon systems were selected to destroy a wide variety of fixed, hard and moving targets. The LARS provides medium tank kill capability from a safe standoff distance of approximately 8,000 feet.

(C) The LARS configuration consists of a standard MK40 2.75 inch Folding Fin Aerial Rocket with a Laser sensitive Proportional Lead Guidance System installed in a launcher attached to the helicopter. A television camera installed on the helicopter "Big U" torquer driven tracking mount provides a real time display of the target area and the tracking mount positioning on the target back at the control van. Automatic mount tracking is achieved through the use of a contrast tracker in conjunction with the TV camera. A laser also mounted on the tracking mount provides target illumination and range information. Documentary photographic coverage is acquired through the use of a 16mm motion picutre camera also installed on the tracking mount. Subsystem and helicopter control is achieved remotely through the use of a Command Control System between the control van and the helicopter. Real time remote monitoring of the essential helicopter and subsystem functions is provided by a telemetry system between the helicopter and the control van.

(C) The flight test program covered by this report was conducted at Nellis Air Force Base, Nevada, from 11 March 1970 through 2 February 1972. Rockets were launched against target boards and typical tactical targets, such as 2 1/2 ton trucks and medium tanks. These launch tests evaluated the ability of the system to hit the desired spot on the selected fixed and moving targets. Other flight tests were conducted to evaluate helicopter reaction when the missile was launched, to determine the pointing accuracy of the tracking mount, to evaluate the contrast tracker and LLLTV for night operations. Seventeen guided missiles and twenty-seven unguided missiles were launched. Approximately 100 flight tests were conducted during the test program.

(C) Testing demonstrated the ability of the missile to hit the laser spot when launched at ranges from 4800 to 6500 feet. Pointing accuracy of the final mount configuration was determined to be $\pm$ .2 mil.

2.0 RESULTS

2.1 Summary of Results

(U) The ARPA NITE GAZELLE/LARS test program was divided into three phases, LARS I and LARS II, and LARS II Night. In all phases guided and unguided missiles were launched from the airborne NITE GAZELLE at ground based targets. Airborne and ground support tests were conducted throughout all phases.

(C) The LARS I test series ran from 10 March through 5 November 1970. The airborne guided missile system was assisted by a ground laser source for target illumination. The LARS missile launcher was located on the "Big U" mount. Test results are summarized in Table 1. Four of the six missile launches were successful. Loss of missile roll control caused the other two missiles to miss the target. During all of these tests the laser illuminator was located on the ground in front of the truck target or target board. Adverse helicopter and tracking mount reactions at launch pointed out the necessity for a new launcher location. These launches effectively demonstrated the concept of Proportional Lead Guidance.

TABLE 1 (Title Unclassified
Table Confidential)

LARS I MISS DISTANCES

Date	Test No.	Slant Rng (ft) at launch	Miss Distance (ft) Right	Left	Up	Down
3/13/70	32	5,500	216			504*
4/15/70	31B	4,800				1
4/17/70	39	5,500				2,000*
10/27/70	67	5,100	1			3
11/3/70	68	5,300		6		4
11/5/70	68A	6,500				11

*Short of Target

(C) The LARS II test series started on 18 November 1970 and was completed on 4 November 1971 with a direct hit on a medium tank. Missile firings were made from a new launcher attached to the side of the helicopter. This location caused excessive helicopter yaw and ground tests were conducted to develop blast deflectors to reduce the yaw to an acceptable value. When tests conducted with the laser illuminator located on the tracking mount showed that the laser spot could not be maintained on the desired impact point, an improved mount was developed that resulted in a pointing accuracy of $\pm$ .2 milliradian. On test 269 the television signal was lost and the operator assumed manual control of the tracking mount and moved the laser spot away from the target. The TV loss was caused by a power fluction on the helicopter. These circuits were changed after this test. Guidance system problems caused the seeker to lock on a fake target return on test 355. Logic circuit changes were made to eliminate this problem.

TABLE 2 (Title Unclassified
Table Confidential)

LARS II MISS DISTANCES

Date	Test No.	Slant Rng (ft) at launch	Miss Distance (ft) Right	Left	Up	Down
2/24/71	262	6,500	1			1/2
2/26/71	263	6,200			1	
3/5/71	266	6,000	6			
3/10/71	269	7,550		6		130*
3/19/71	272	6,000	4		1 1/2	
10/14/71	354	4,800	10		10	
10/29/71	355	6,000		500		1,650*
11/4/71	356	6,200	Direct Hit			
11/4/71	357	5,500		4		

* Short of Target

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(C) The LARS II (Night) test program was conducted from September 1971 through 2 February 1972. Although both missiles launched at night missed the tank target the feasibility of night launches was demonstrated and techniques can be changed to insure the success of missiles launched at night. Several low light level television configurations were tested. The final one was able to detect targets in moonlight and provide a contrast difference great enough for contrast tracker operation. The flash of the missile firing saturated the low light level television, caused the contrast tracker to lose lock and position the laser spot away from the target. Circuit changes were made to inhibit the television and mount drive systems during the time the rocket motor was burning. Unguided missiles proved that these circuits worked as expected. The laser target illuminator was located on the tracking mount during this test phase.

TABLE 3 (Title Unclassified
Table Confidential)

LARS II (NIGHT) MISS DISTANCES

Date	Test No.	Slant Rng(ft) at launch	Miss Distance (ft) Right	Left	Up	Down
1/31/72	428	6,000	Not	Determined		
2/2/72	429	8,100		100		

2.2 Discussion of Test Results

2.2.1 LARS I

(C) Eight missiles were developed to demonstrate the basic concept of Proportional Lead Guidance. The first flight occurred at Avon Park, Florida, and the results were so successful that the program was expanded to investigate the compatibility of the helicopter missile launchers and guidance system accuracy. The flight test program was transferred to Nellis AFB, where the expanded scope of the program could be effectively tested. Six guided missile launchings were completed during the Nellis test phase. Four of the six flights impacted within eleven feet of the target's center. The LARS I test program was completed with one unexpended missile which was modified and transferred to the LARS II test program.

(U) All live launch tests of the LARS I series utilized a laser target illuminator located on the ground at varying distances in front of the target. Since the laser spot was illuminating the desired impact point, the miss distances represent the impact from the center of the target and from the aimpoint.

(C) Loss of missile roll control occurred on test number 32 and 39. This problem was corrected by a design change in the external configuration

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of the missile. The performance on the last three flights in this series demonstrates the success of this modification.

(C) The LARS I field test program successfully demonstrated the basic concept of Proportional Lead Guidance. Investigation of the causes for the consistently low impacts resulted in the discovery of design errors. Modifications were implemented in time to be included in the LARS II program.

(C) The test program also resulted in the determination of a minimum range of 5,200 feet from the target at launch time. This range provides adequate flight time for the guidance system to remove all transients caused by the launch impulses.

(U) A total of twenty-four flight tests were completed to prove the expanded list of test objectives. A list of all test activity is arranged in chronological order in Appendix B and detailed test information is contained in Appendix C.

Missile Roll Control

(C) Loss of roll control occurred on test 32 and test 39. Investigation revealed five major causes. Loose tolerances in the tail fin assembly allowed $\pm$ 1.5 degrees of freedom in this angular position. This resulted in the center of pressure moving forward and causing pitch and yaw instability. The long missile body resulted in bending between the fore and aft sections which also caused the center of pressure to shift forward. Nonlinear optics caused pitch and yaw error outputs to vary with gimbal angles. Roll also is induced by vane shading by the missile body. Normally this effect is insignificant. However, when combined with the other problems, it was a significant contributor to the loss of roll control. The missile was approximately two pounds lighter than anticipated which resulted in a higher velocity which amplified the effects of the first two defects.

(C) The following actions were taken on the remaining LARS I missiles to eliminate this problem:

> The tolerances on the tail fin assembly were reduced to improve tail effectiveness. A new swept canard was developed to reduce the induced roll by 75% and the total weight was increased.

These changes effectively eliminated loss of roll control as demonstrated by the successful launches which occurred after these fixes were installed.

Accuracy Improvement

(C) A detailed analysis of the consistently low impacts which occurred in the LARS I series determined the cause to be a combination of a low normal

force coefficient and lower than expected terminal velocity. Changes made to the LARS II missiles, prior to testing, to eliminate this problem were:

1) Canard size was increased to provide more normal force coefficient.
2) The seeker head bias was increased from 2 to 3 degrees. This change causes the missile to trim out at a higher angle of attack and fly above the line of sight rather than below it.
3) Final weight was reduced.

Impact data from the LARS II test program have demonstrated how successful these modifications were.

2.2.2 LARS II

(C) Successful completion of the LARS I test series, which confirmed helicopter/weapon compatibility, lead to the LARS II test series for which twelve additional guided missiles were developed with design improvements. Nine of these were launched during the day, two at night and one was returned to the manufacturer. The requirement for a ground laser source for target illumination was eliminated when the laser source was installed on the "Big U" mount. This made a complete, self-contained, airborne LARS capable of mobile interception of enemy targets. A new launcher was developed and installed on the side of the helicopter to separate launch effects from the contrast tracker and laser operation. In addition to the guided missile launches over twenty tests were conducted in the LARS II test series. Results of the guided missile launches are summarized in Table 2. A list of all test activity is contained in Appendix B and detailed test reports are contained in Appendix C.

(U) The miss distances in Table 2 represent the distance from the actual impact to the desired impact point. Where the ground illuminator was used (tests 262, 263, 266 and 272), the laser was pointed at the target. On tests with the airborne illuminator, the miss distances are measured from the target center so they represent missile accuracy combined with laser pointing accuracy.

(C) Immediately after the missile was launched on test 269, all TV signals from the helicipter were lost. When the operator assumed manual control at 1.5 seconds prior to impact, the contrast tracker had lost lock and the laser spot had drifted off the target. Analysis of telemetry signals from the missile showed that the seeker followed the spot throughout the flight and was positioned on the spot at impact. Analysis of telemetry data obtained on test 355, and on later captive flights, revealed a circuit deficiency that allows the laser seeker to track backscatter. A modification was added to eliminate this problem. The LARS II test program successfully demonstrated the effectiveness of the modification to eliminate low impacts and to

improve the accuracy of the missile. The deviation of 4 feet to the right of the laser spot, on test 272, occurred in a 20 mile per hour crosswind. The largest deviation of the successful day missile launches (10' right, 10' up) occurred because the launch range selected (4,800 feet) did not provide adequate flight time for the missile guidance system to remove transients caused by the launch. Laser pointing through use of the contrast tracker was sufficient to hold the laser spot at a designated area on a moving tank.

Smoke Obscuration of the Target

(C) When a missile was launched, smoke from the burning propellant obscured the target and caused the contrast tracker to lose lock. Testing revealed that the missile could be launched at an angle of 1.5 degrees from the axis of the helicopter heading. This technique kept the missile out of the field of view of the tracker during the launch phase and effectively solved this problem.

Turntable Tests

(C) During launches with the launch tube mounted on the side of the helicopter, a helicopter yaw displacement of approximately five degrees was observed. Analysis showed that the helicopter yaw was caused by missile friction in the launch tube and by missile exhaust gasses hitting the air frame. An extensive ground test program, with the helicopter mounted on a turntable, resulted in the design and installation of deflector plates, which deflected the exhaust gasses and eliminated the yaw displacement.

Laser Pointing Accuracy

(C) Laser pointing accuracy is critical to the success of the LARS weapon system. A stable mount, which insulates the laser illuminator from shock forces at the time of launch, is essential so that the laser spot can be maintained on the intended target. Pointing accuracy was measured with respect to an unmarked point in the center of the turret on test 356 and is displayed in Figure 2. The time interval used covers the period from about two seconds prior to launch to impact. The missile flight duration was about eight seconds. The standard deviation in azimuth was .41 mil, the standard deviation in elevation was .09 mil and the radial standard deviation was .42 mil.

2.2.3 LARS II (Night)

(C) Thirty-three tests were completed during this test phase. Two guided missiles were launched to determine the ability of the system to hit a tank target at night. Six unguided missiles were launched to evaluate low light level television and contrast tracker performance at night. The remaining checks were made to evaluate various systems as changes to hardware and procedures were completed.

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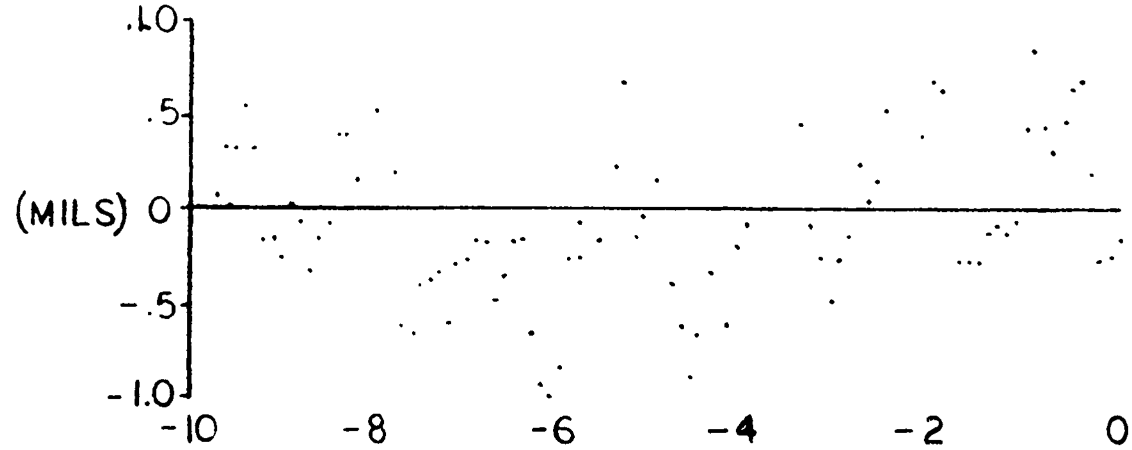
LASER POINTING ACCURACY
LARS TEST NO. 356

DEVIATIONS IN PAN



DEVIATIONS IN TILT

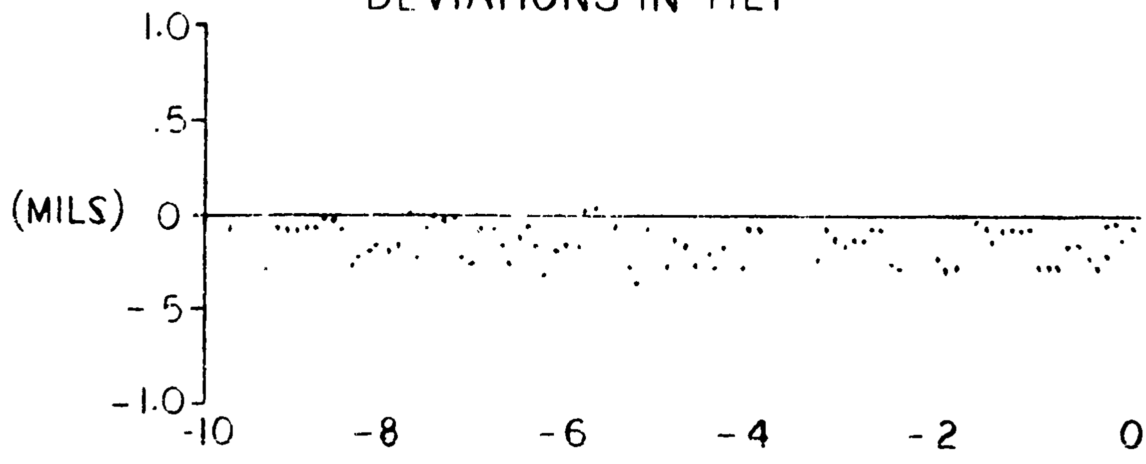


Figure 2

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(C) Helicopter 1726 was used at the beginning of this test phase. In September the new McMaster servo motors were installed to eliminate mount oscillations. Pointing accuracy was not completely satisfactory and in January the 1725 helicopter, used so successfully during the day launches was configured to support night launches.

(C) On test 428, the first night launch, unexpected missile debris passed through the contrast tracker track gate and caused the system to lose lock on the target. When the tracker loses lock drive signals are no longer being applied to the mount and it loses the capability to point the laser at the target. On this test, the laser spot moved over the target, the missile followed the spot and impacted beyond the target.

(C) On test 429, the contrast tracker lost lock when a bright spot appeared in the center of the TV field of view. When the TV inhibit cycle was completed the TV monitor showed that the missile had entered the upper right corner of the screen and passed out the lower left side. The contrast tracker track gate was positioned on the trail left by the missile and it started to track this contrast difference. The operator observed what happened and assumed manual control of the mount to reposition the laser spot on the target. The remaining flight time was too short for the guidance system to fly the missile to the target and impact occurred approximately 100 feet left of the target.

(C) The laser pointing accuracy on these tests was excellent. On test 429, the contrast tracker achieved lock at a helicopter-to-target range of 12,000 feet. Launch occurred at 8100 feet and was the greatest range of the program.

3.0 SYSTEM DESCRIPTION

(C) The Laser Aided Rocket System (LARS) consists of a standard MK40 2.75 inch Folding Fin Aerial Rocket modified by the addition of a Proportional Lead Guidance System. When the target is illuminated by a laser the seeker head of the missile guidance system locks on the reflected laser signal. In flight, the output of the guidance system provides continuous corrections to the missile control system which guides the missile to impact on the laser spot. The LARS I missiles were launched from a tube attached to the tracking mount of the NITE GAZELLE helicopter (See Figure 3). A new launcher was developed for the LARS II program and was mounted on the side of the helicopter (See Figure 4). In addition to the normal NITE GAZELLE remote flight and weapon control systems, a laser target illuminator, television camera and a contrast tracker were installed on the helicopter. A complete description of the system is presented in Appendix A.

LARS I on the 'Big U' Mount

Figure 3

LARS II Launcher

Figure 4

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The main objectives of this test program were:

1) Demonstrate the Proportional Guidance concept.
2) Determine helicopter and tracking mount performance at launch.
3) Determine helicopter pointing capability.
4) Determine laser pointing capability of the tracking mount.
5) Determine the ability of the integrated system to hit stationary and moving targets at night as well as during daylight hours.
6) Determine the effect of rocket flame effects on contrast tracker/TV performance.

4.2 Test Plan

(C) Guided missiles were launched at stationary and moving targets located in the desert bombing range. Unguided missiles were launched while the helicopter was on the pad and during flights over the test range. Captive flights to obtain signal strength data and tests to determine tracking mount performance were made against targets located on the test range.

(C) Test runs were conducted at altitudes from 500 to 1,200 feet and airspeeds from 5 to 64 knots. The impact location of the guided missiles was measured and recorded. Signal strength data were telemetered to the ground station, recorded and reduced. Pointing information was recorded on video tape and 16mm film and measurements were made to determine where the mount was actually pointed.

(U) Individual test plan details are contained in Appendix C along with test objectives and test results. The general configuration of the Nellis Test Range is shown in Figure 5.

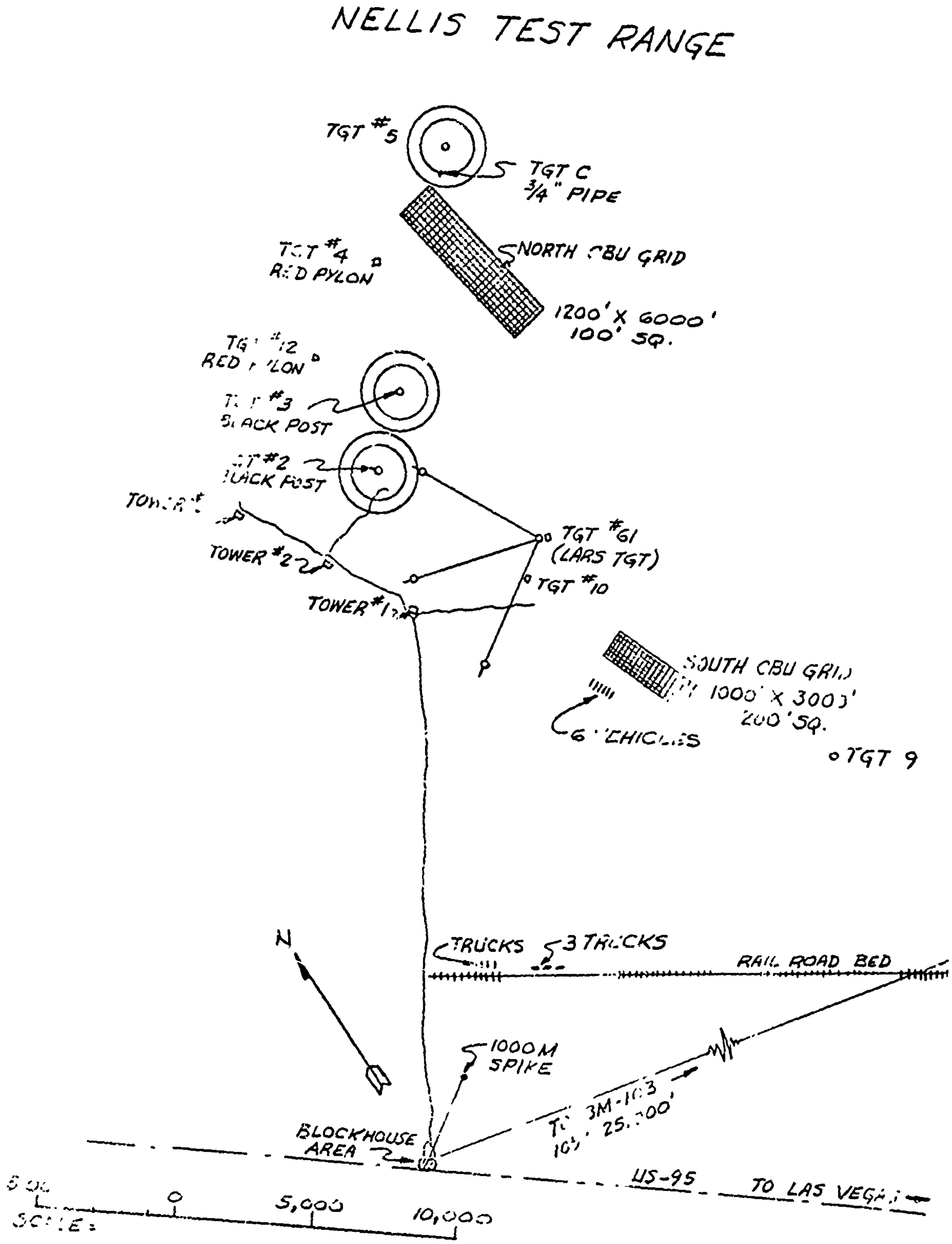
NELLIS TEST RANGE
TGT #5
TGT C
3/4" PIPE
NORTH CBU GRID
1200' X 6000'
100' SQ.
RED PYLON
TGT #61
(LARS TGT)
TGT #10
TOWER #2
TOWER #1
SOUTH CBU GRID
200' SQ.
TGT 9
N
TRUCKS
RAIL ROAD BED
1000 M
SPIKE
BLOCKHOUSE
AREA
US-95
0
5,000
10,000

Figure 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the following areas:

- Missile
- Helicopter
- Data Link
- Ground Station
- Television
- Contrast Tracker
- Tracking Mount
- Launcher

5.1 Missile

5.1.1 Conclusion

(C) The performance of the missile was sufficient to impact the missile on the desired target area from a distance of 6,200 feet. However, one missile launched during the day and two missiles launched at night missed the desired impact point. These misses were caused by a combination of problems and two of these were associated with the guidance system. The system is overly sensitive to laser reflections from the near field and "hard over" commands are given when the missile axis is more than 2 degrees offset from the target.

5.1.2 Recommendation

(C) The guidance system should be improved to reduce the sensitivity to reflections received from the near field and to decrease the possibility of tracking on a side lobe. The system should also be modified to delay the initiation of "hard over" commands. This delay will keep the missile out of the field of view of the television camera and prevent tracker unlock.

5.2 Helicopter

5.2.1 Conclusion

(U) The helicopter proved to be a reliable vehicle during the test program.

5.2.2 Recommendation

(U) None

5.3 Data Link

5.3.1 Conclusion

(U) The data link performance for command data to the helicopter and response data from the helicopter and missile was satisfactory.

5.3.2 Recommendation

(U) None

5.4 Ground Station

5.4.1 Conclusion

(U) The ground station proved to be effective for all aspects of the test program.

5.4.2 Recommendation

(u) (U) None

5.5 Television

5.5.1 Conclusion

(C) The high resolution television system used for the day launches provided satisfactory information for target location and identification. The low light level television system used for night launches was susceptible to the rocket flame.

5.5.2 Recommendation

(U) The techniques to use this system at night have been completed. Additional testing should be conducted to evaluate performance on more night launches.

5.6 Contrast Tracker

5.6.1 Conclusion

(U) The contrast tracker operation was satisfactory.

5.6.2 Recommendation

(U) None

5.7 Tracking Mount

5.7.1 Conclusion

(U) The tracking mount was able to provide a stable platform for the laser illuminator and the contrast tracker. Final performance figures indicate a ±0.2 milliradian tracking accuracy. The final direct drive mount configuration that resulted in the tracking accuracy of ±0.2 milliradian weighs 230 pounds more than the modified servomotor gearhead mount that provided a tracking accuracy of ±1.0 milliradian. A lightweight direct drive system, under development, can reduce mount weight by 120 pounds.

5.7.2 Recommendation

(U) The lightweight direct drive system should be developed for systems that require the ±0.2 milliradian accuracy. For other programs, the modified servomotor gearhead system should be used.

5.8 Launcher

5.8.1 Conclusion

(U) The missile launcher performance was satisfactory throughout the test program. However, it has the capability to launch only one missile per flight.

5.8.2 Recommendation

(U) Multiple missile launch capability should be developed.

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GLOSSARY

ARPA	Advanced Research Projects Agency
A/S	Airspeed
DAME	Distance and Azimuth Measuring Equipment
FFAR	Folded Fin Aerial Rocket
FM	Frequency Modulation
HE	High Explosive
LARS	Laser Aided Rocket System
LLLTV	Low Light Level Television
PAM	Pulse Amplitude Modulation
PLG	Proportional Lead Guidance
OD	Olive Drab
RFI	Radio Frequency Interference
SS	Signal Strength
SR	Slant Range
TLM	Telemetry
W/H	Warhead

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APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(U) The system under test cons[illegible]ted of a standard MK 40 2.75 inch Folded Fin Aerial Rocket (FFAR) modified by the addition of a Proportional Lead Guidance System. The rocket was launched from a remotely piloted helicopter.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE Remotely Piloted Helicopter is a modified counter-rotating double bladed helicopter, which was originally developed by the U.S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding a 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius of the NITE GAZELLE/LARS Weapon System is 35 miles with 30 minutes on station.

2.2 The Surveillance Tracking and Weapons Mount

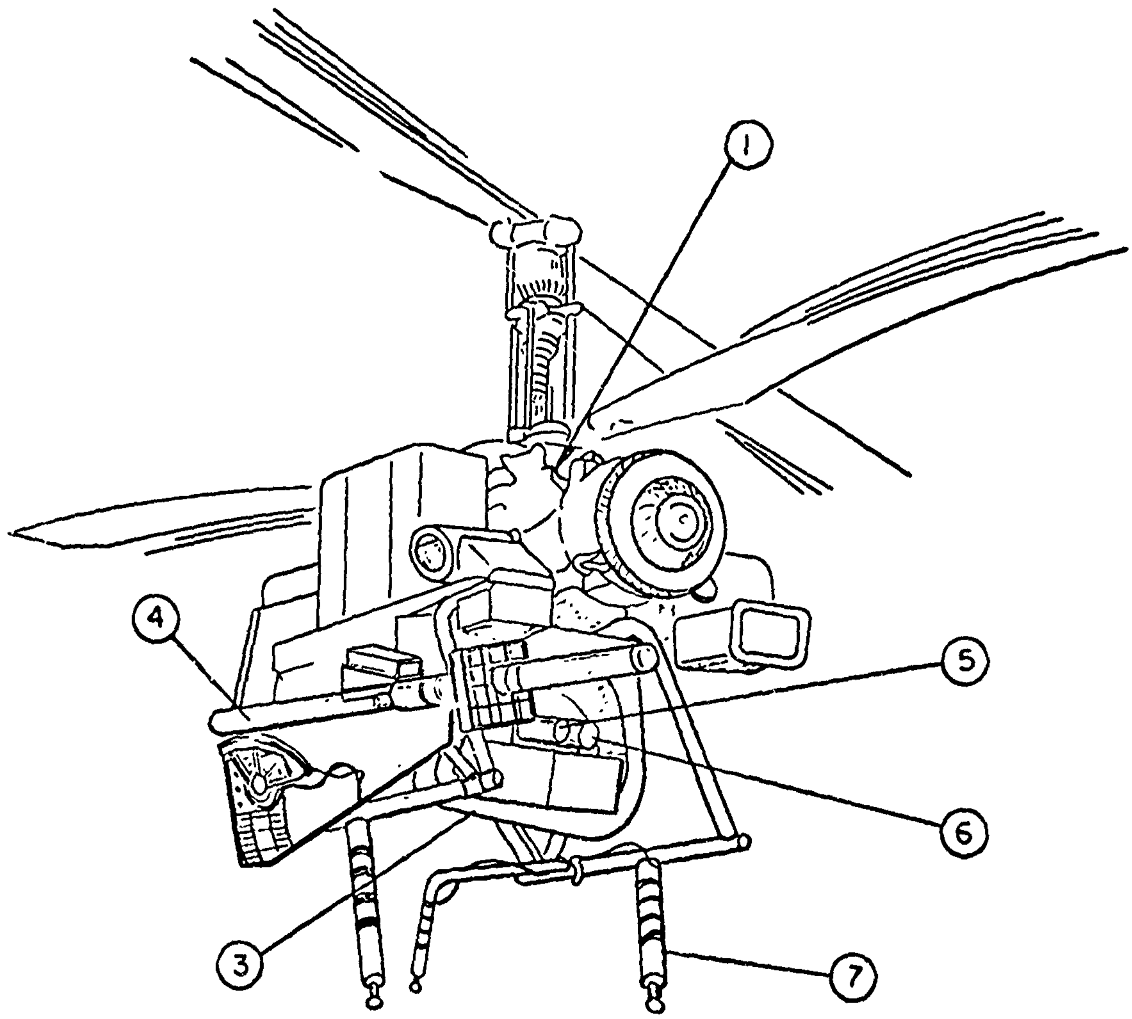
(U) The "Big U" is a rate commanded inverted U-shaped gyrostabalized weapon/sensor mount. The sensors and the LARS I launcher were mounted on a platform suspended between the two arms of the "Big U".

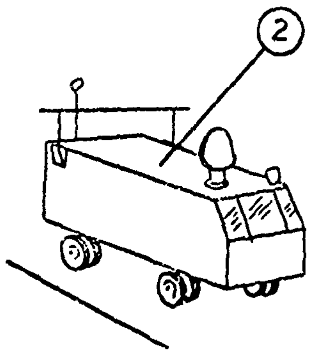
(U) The platform is remotely controlled in pan and tilt for accurate target tracking. The "Big U" can be moved through a traverse angle of ±25 degrees at a maximum pan rate of 3 degrees per second. The platform can be depressed from the horizontal to -100° at a maximum tilt rate of 3 degrees per second.

(U) The mount is centrally located under the drive shaft to provide maximum stability during in flight operations. However, the original mount configuration did not provide adequate stability for airborne laser pointing. A design change was made that provided a tracking accuracy of ±1 milliradian. However, when the missile was fired it rotated the helicopter and caused the contrast tracker located on the mount to lose lock. The mount gear ratios were reduced and the servo motor gearhead was improved to keep the tracker locked when the missile fired. This change resulted in a pointing accuracy of ±0.5 milliradians. Direct drive torquers were added and airborne laser pointing accuracy has been measured as ±0.2 milliradians. This final configuration was used on tests 356 and 357 and direct hits were scored.

2.3 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable





NITE GAZELLE/LARS

1. HELICOPTER DRONE QH-50D (UNFAIRED)
2. NITE GAZELLE CONTROL VAN
3. SURVEILLANCE TRACKING & WEAPON MOUNT "BIG U"
4. LAUNCH TUBE
5. 16MM MOTION PICTURE CAMERA
6. DAY TELEVISION
7. ANTENNA

Figure A-1

type van that contains a pilot's position for remote control of the helicopter, and a weapon controller's position for target acquisition and optical fire control capability.

(U) Three radio links connect the helicopter and the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data are sent to the ground via an S-band link, and TV imagery is transmitted via an L-band link.

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communications relay system, permits operation beyond ground line of sight. DAME data are used to chart the helicopter's pos'' ᴗ. on a plotting board at the side of the controller's position.

(U) The weapons controller monitors the surveillance tracking and controls the mount while viewing TV video. He controls the TV camera zoom lens, the 16 mm film camera and transmits the firing signal.

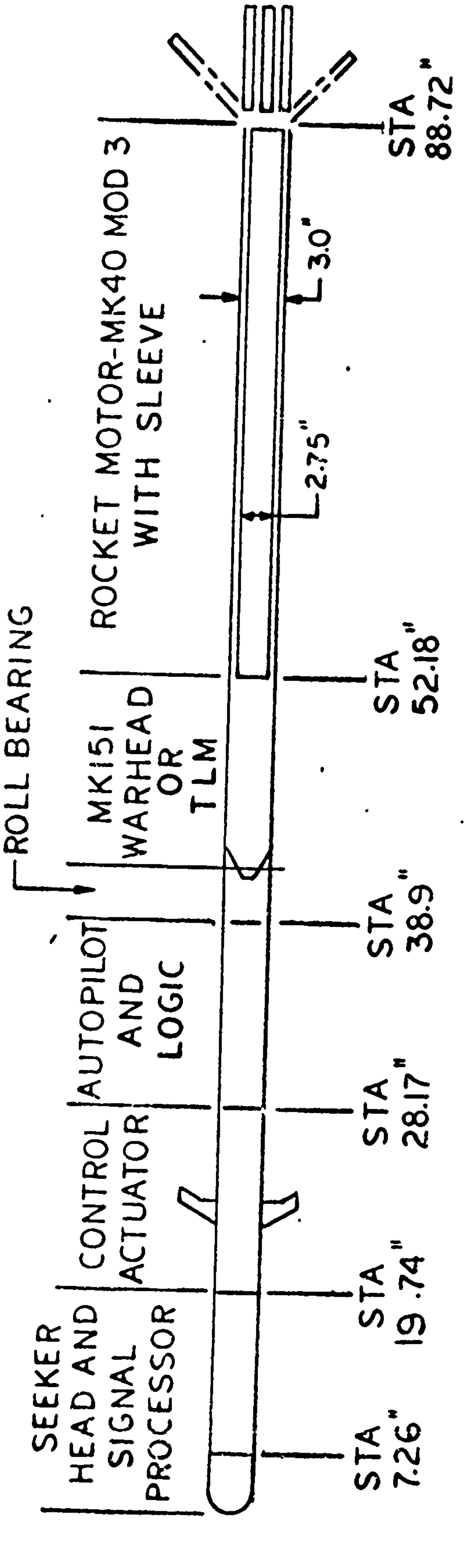
2.4 Laser Aided Rocket System (LARS)

2.4.1 General

(C) The LARS is fired from a tube mounted on the helicopter. The missile is inserted from the front and only approximately five minutes are required to complete the loading. When missile loading and ground checks are complete, the pilot takes off and heads for the target area. Navigation is accomplished by observing the position of the helicopter on the plotting board. The day and night television systems are used to recognize landmarks and to seek out potential targets. When a target is selected, the pilot starts his firing approach from a slant range of approximately twelve thousand feet from the target. The laser target illuminator is turned on and laser reflections should be observed by ten thousand feet. The ground controller observes the target by means of the TV system, positions the laser spot at .e desired impact point and places the contrast tracker in the automatic track mode. He also monitors signals from the LARS and when all parameters are in a "go" condition, he fires the missile through the use of the command control system.

2.4.2 LARS I

(C) The Laser Aided Rocket System (LARS) is the first generation of a modification adding guidance and control capability to a standard MK 40, 2.75 inch Folding Fin Aerial Rocket (FFAR). This configuration uses a semi-active laser seeker Proportional Lead Guidance (PLG) and a MK 151 warhead. Figure A2 is a drawing showing the physical dimensions of the missile and the



LARS PHYSICAL DIMENSIONS

FIGURE A2

guidance concept is described in paragraph 2.4.3. The seeker head has a ±7.5 degree field of view. Laser energy and background energy enters through the optical dome and passes through a narrow optical band pass filter. This filter eliminates most of the background light while the reflected laser energy is passed on to a quadrant detector. The relative magnitudes of the four quadrant signals are used to determine pitch and yaw correction signals to guide the missile to the target.

(C) After the second missile failure, on 17 April 1970, an instrumentation system was developed and installed on board the missile to provide performance information during flight. A PAM/FM/FM telemetry system was installed in the space normally occupied by the explosive warhead. A self-contained power supply permits operation of the telemetry system independent of the missile primary power. The transmitter frequency is approximately 250 MHz and the 0.3 watt power output provides an effective range of five miles. These UHF signals are received and recorded on magnetic tape at the telemetry ground stations.

2.4.3 Proportional Lead Guidance System

(U) The concept of PLG can be understood by analyzing Figure A3 which shows a simplified version of the basic guidance loop. The line of sight angle λ and the seeker altitude angle θ_s are summed to obtain the guidance error signal ϵ. This error signal drives the autopilot and airframe dynamics, yielding the missile altitude ϵ_m. The seeker is then driven toward the missile axis at a rate proportional to the gimbal angle:

$$\dot{\theta}_s = \frac{1}{\tau_s} (\theta_m - \theta_s)$$

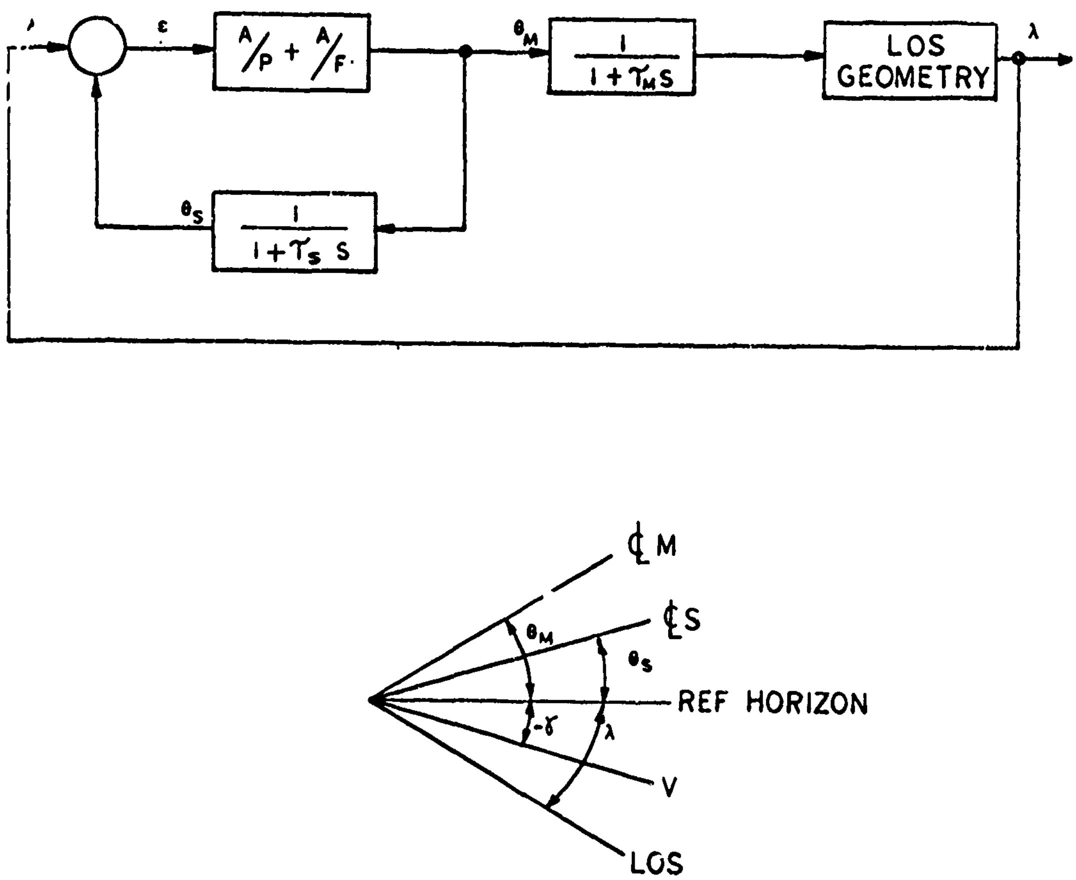
This results in a first order lag between the missile and seeker axis, completing the tracking loop:

$$\frac{(\theta_s)}{(\theta_m)} = \frac{1}{1+\tau_s S}$$

(U) The missile dynamics produce a simila‹ ‹ag between the missile altitude and velocity angle γ. Missile motion is then related to line of sight changes through the line of sight geometry, completing the guidance loop.

(U) If the tracking gain and stability are sufficient, the guidance error will stay small, so that

$$\theta_s = -\lambda \qquad (1)$$



PLG GUIDANCE SYSTEM

Figure A-3

Taking into consideration the relationship of Θ_s to Θ_m, and γ to Θ_m:

$$\Theta_s = \frac{\Theta_m}{1 + \tau_s S} \quad \text{and} \quad \gamma = \frac{\Theta_m}{1 + \tau_m S}$$

(1) becomes

$$\frac{1 + \tau_m S}{1 + \tau_s S} \gamma \approx -\lambda \text{ or } \left(\frac{\gamma}{\lambda}\right) \approx - \frac{1 + \tau_s S}{1 + \tau_m S} \qquad (2)$$

Alternately,

$$1 + \tau_m S \, \gamma \approx -(1 + \tau_s S) \lambda ,$$

$$\gamma + \tau_m \, \dot{\gamma} \approx -\lambda_s - \tau_s \lambda \quad \text{or}$$

$$(\lambda + \gamma) \approx -(\tau_m \dot{\gamma} + \tau_s \dot{\lambda}) \qquad (3)$$

In a steady state situation $\dot{\gamma} = -\dot{\lambda}$, so that

$$(\lambda + \gamma) \approx -(\tau_s - \tau_m) \dot{\lambda} \qquad (4)$$

This relationship indicates that in steady state, the missile velocity vector leads the line of sight (if $\tau_s > \tau_m$) by an angle proportional to the line of sight rate.

(U) The $\frac{\gamma}{\lambda}$ transfer functions derived above (2) provides a means of comparing PLG with proportional navigation (PNG). The magnitude of $\frac{\gamma}{\lambda}$ corresponds to the PNG navigation ratio. At the higher frequencies which are dominant in establishing guidance accuracy, the gain approaches τ_s / τ_m. Accordingly, the performance of a PLG system can be expected to approximate that of a PNG system with a navigation ratio of τ_s / τ_m.

2.4.4 LARS II

(C) The physical dimensions and general performance characteristics of the LARS II missile are the same as the LARS I. Improvements were made in the guidance system to eliminate the low impact problem that was detected during the LARS I test program. A new launcher was developed to eliminate adverse "Big U" mount reactions when the missile was launched. This launcher is attached to the right side of the helicopter and, therefore, cannot be moved in the azimuth plane. The launcher utilizes the output of the missile guidance to track in the vertical plane. This arrangement allows the flight

controller to concentrate on maintaining the required helicopter heading.

2.5 Day Television System

(U) The day television system is used as the primary daytime sensor on the NITE GAZELLE/LARS Weapon System. The camera system is manufactured by COHU Electronics Corporation. The cylindrical camera unit is 4 inches in diameter, 19 inches long and weighs 11 pounds. Resolution is 945 lines at one foot candle illumination on the face plate. The camera control unit weighs 15 pounds.

(U) The camera lens is a 15 mm to 150 mm zoom with a 2X extender changing focal length and zoom to 30 mm to 300 mm, f5.6 to f22, covering a field of view of 23 degrees down to 2.3 degrees at full zoom. The zoom and f-stop and focus are remotely controlled from the fire controller's station on the ground. A projected reticle with a remotely controlled intensity is also provided.

(U) The TV transmission bandwidth is 14.8 MHz, with a power requirement of 45 watts.

2.6 Low Light Level Television (LLLTV)

(U) An active gatable ISOCON Low Light Level Television (LLLTV) is the primary nighttime sensor used on the NITE GAZELLE/LARS Weapon System. The system has the capability to illuminate the target and provide a variable range gated format. Two camera heads were tested; one designed by General Electric Company and the other provided by the Air Force. The GE camera head weighs 47 pounds and is 4 pounds heavier than the Air Force head. Other components of the system weigh one hundred forty pounds. The resolution measured with an 875 TV line system is 720 lines at 10^{-5} foot-candle illumination on the face plate.

(U) The camera lens has a focal length of 410 mm, T number of 2, and a field of view of 4.8 degrees by 3.6 degrees. The illuminator has a Gallium Arsenide Emitter operating at a wavelength of 0.85 microns. The pulse width is one microsecond, average power is 6.5 watts and the illuminated field is 2 degrees horizontal by 1.5 degrees vertical. Liquid nitrogen is used as a coolant and provides an operating time of over four hours.

2.7 16 mm Motion Picture Camera

(U) The 16 mm motion picture camera is co-mounted beside the TV camera. A filmed record of the mission is obtained for post-flight evaluation.

(U) The camera is manufactured by Photosonics and operates at a frame rate of 24 to 200 frames per second. It is fitted with a 25 to 250 mm zoom lens with a normal aperture of f2.8-22. The focal length is remotely

controlled in flight to maintain proper magnification and field of view to document the mission. The on board exposure control unit is automatic.

2.8 Laser Illuminator-Ranger

(U) The laser illuminator-ranger, manufactured by International Laser Systems, is a cylindr cal unit 4 1/2 inches in diameter, 22 inches long and weighs 14 pounds. It operates at a wavelength of 1.06 microns, has a pulse width of 15 nanoseconds and produces 178 millijoules per pulse and operates single pulse, one pulse per second or 10 pulses per second. It has an effective range of 10 km and a range accuracy of ±5 meters.

2.9 Contrast Tracker

(U) The development of the NITE GAZELLE contrast tracker was based on a TV edge tracker similar to those used by Navy and Air Force air-to-surface missiles. The contrast tracker provides an automatic track mode for the "Big U" mount and gives the operator the capability to select the place on the target where the laser will be pointed. It is normally operated with the TV lens set at full zoom which provides a field of view of 2.3 degrees. The track gate is 1/40 of a horizontal scan or equivalent to 1.3 milliradians.

(U) In operation, the operator searches for a target by means of the day or LLLTV system. When a target is selected, the operator moves the mount until an area of high contrast appears in the tracking gate; he then switches to the automatic tracking mode. In this mode, the mount follows the target and it appears to be stationary while the background moves. While in the automatic track mode, the operator offsets the track gate to align the electronic cursors over the point to be illuminated by the laser spot. The contrast tracker continues to track the area of high contrast and the laser spot which is boresighted to the cursors remains fixed on the desired impact point. In the event of a malfunction, the operator can regain control of the mount and manually track the target by keeping the cursors on the desired impact point.

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR LARS I

Date	Test No.	Plan	Comments
3/11/70	31	Check Flight	Satisfactory
3/11/70	31	Check Flight	Cancelled because of high winds.
3/11/70	31A	Launch a dummy missile.	Fuse blew on DAME on first pass. Was replaced and missile was launched.
3/12/70	32	Launch guided missile with an inert warhead to check configuration.	Cancelled because of RFI
3/12/70	32	Check flight to investigate RFI	RFI still affecting TLM and DAME.
3/13/70	32	Launch guided missile with inert warhead at a stationary truck target.	First run cancelled in flight when the mount hit the stops. Launched on second pass, 504' short, 216' right.
3/16/70	32A	Launch guided missile with inert warhead.	Cancelled when extraneous light reflections were observed in the impact area.
3/16/70	32A	Launch guided missile with inert warhead.	Cancelled in flight when telemetry signals from the vehicle were lost. A hard landing damaged a fuel line.

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Table B-1 Continued

Date	Test No.	Plan	Comments
3/17/70	32A	Check flight to look for spurious signals.	Cancelled because of severe telemetry interference.
3/17/70	32A	Check flight to check telemetry performance.	Three runs completed. Telemetry performance was satisfactory.
4/6/70	61	Captive flight to scan the 3' x 3' aluminum target. Illuminator at 1500'.	Cancelled when calibrations could not be completed in allotted range time.
4/7/70	61	Captive flight to scan the 3' x 3' aluminum target. Illuminator at 1500'.	Five runs were completed.
4/7/70	62	Captive flight to scan OD truck target. Illuminator at 1500'.	Three runs were completed.
4/8/70	62	Captive flight to scan OD truck target. Illuminator at 1500'.	Four runs were completed.
4/8/70	63	Captive flight to scan OD truck target. Illuminator at 5000'.	Four runs were completed.
4/10/70	31A	Launch unguided missile to test helicopter/missile interactions.	Three passes cancelled because of helicopter navigation problems. Fired on fourth pass.
4/10/70	64	Captive flight to scan a truck target. Illuminator at 50'.	Six runs successfully completed.
4/14/70	31B	Launch guided missile with high explosive warhead, inert fuse at panel on fender of OD truck.	Four passes cancelled because of helicopter location.

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Table B-1 Continued

Date	Test No.	Plan	Comments
4/15/70	31B	Launch guided missile with high explosive warhead, inert fuse on fender of OD truck.	Successfully launched on first pass at 4800 foot slant range. Impact was one foot low.
4/16/70	39	Guided missile launch - live warhead - truck target. Illuminator 500' from target.	Cancelled because of a TV failure three minutes after launch.
4/17/70	39	Guided missile launch - live warhead. Illuminator 500' from target aimed at panel on hood of OD truck.	Launched at 5000 feet on first pass. Missile impacted 2000 feet short.
10/2/70	66	Captive flight to evaluate seeker performance with ground illuminator.	Cancelled because sufficient range time was not available.
10/2/70	66	Captive flight to evaluate seeker performance with ground illuminator.	Cancelled when all missile guidance signals were lost. Missile rotation in the launcher severed a connector.
10/9/70	-	Check flight to evaluate tracker performance. Ground illuminator/ dummy missile in launch tube.	Four runs completed. Tracker was observed to lose lock when airspeed abruptly changed.
10/9/70	-	Check flight to evaluate tracker performance. Ground illuminator/ dummy missile removed.	Four runs completed.
10/13/70	-	Check flight to evaluate tracker.	Cancelled when all command signals to the aircraft were lost.

Table B-1 Continued

Date	Test No.	Plan	Comments
10/14/70	-	Check flight to evaluate tracker.	Cancelled while command repairs were made.
10/14/70	-	Check flight to evaluate tracker.	Fourteen runs completed. Tracker loses lock when sudden speed changes occur and at activation of firing circuit. Does not lose lock when field of view is doubled.
10/21/70	31C	Launch of unguided inert warhead rocket to check LARS/ helicopter interactions.	After a successful dry run, the missile was launched on second pass. Smoke obscured the target and the mount became unstable.
10/26/70	66	Acquire signal strength data. Laser at 7000', 5000' and 4000'.	Data were collected.
10/27/70	67	Guided missile launch with TLM. Inert warhead. 20' x 20' target. Illuminator 500 feet from target and 30° offset from run in line.	Tracker lost lock for one second. Mount pitched up 1.2° at launch. Impact was 3 feet low and 1 foot right of laser spot. Launch occurred at 5100 feet.
11/3/70	68	Guided missile launch. Inert warhead. Illuminator is 500 feet in front of and offset 30° of target, aimed at hood of truck.	First pass was a successful dry run. Launch at 5200 feet on second pass. Tracker lost lock. Impact was six feet left and four feet low. Mount pitched up 1.7° at launch.
11/5/70	68A	Guided missile against a moving truck target. Inert warhead. Illuminator located on a platform on the truck. Missile TLM.	Flight aborted when truck lost remote control capability.

Table B-1 Continued

Date	Test No.	Plan	Comments
11/5/70	68A	Guided missile against a target located on a stationary truck. Inert warhead.	Severe mount movement at launch. Impact was eleven feet low. Launch occurred at 6500 feet.

TABLE B-2 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR LARS II (Day)

Date	Test No.	Plan	Comments
11/18/70	230	Flight to determine the ability of helicopter to point in yaw with mount locked in azimuth.	High winds prevented lock on runs 1 and 2. Third run was satisfactory.
11/18/70	230A	Flight to determine the ability of helicopter to point in yaw with mount locked in azimuth.	Four runs successfully completed.
2/18/71	285	Launcher temperature test.	Engine exhaust does not heat launcher. 26 minute flight.
2/18/71	260	Obtain S/S vs range data. Verify pointing ability.	Five runs completed. Heading hold varied from $\pm$ .750 at 50 knots airspeed to $\pm$ 3 degrees at 15 knots. Yaw rate changes are within tolerance. S/S data -25 db above threshold. 5 db is required.
2/18/71	261	Unguided dummy launch to evaluate transient launch effects.	After first dry run, missile was launched at S/R of 6, 000 feet. No problems noted.
2/19/71	262	Guided launch - ground illuminator. Evaluate LARS II flight characteristics.	Cancelled because of heavy rain.

Table B-2 Continued

Date	Test No.	Plan	Comments
2/22/71	262	Guided launch - ground illuminator. Evaluate LARS II flight characteristics.	First dry run satisfactory. Tracker did not lock on second run. Laser failed on 3rd run.
2/24/71	262	Guided launch at target board with ground illuminator located 500 feet in front of target. Evaluate LARS II flight characteristics.	Impact one foot right, 1/2 foot down from bull, but in center of beam. Mount elevated 5 degrees. Slant range of 6500 feet. Aircraft yawed 4 degrees.
2/26/71	263	Launch to confirm flight characteristics, warhead capability. Ground illuminator 500 feet from tank target.	Run #1 cancelled because of excessive drift rate. Launched at 6200 feet. Impact occurred within one foot of where spot was pointed. Warhead did not explode.
3/2/71	286	Pointing accuracy test using airborne laser.	Two runs successfully completed. Tracking error varied from .75 to 1.9 mils.
3/2/71	264	Captive LARS II.	Cancelled because of range time conflict.
3/3/71	264	Captive flight to determine the ability of the Big U Mount to point the airborne laser. Measure S/S vs range. Verify helicopter pointing ability.	First run satisfactory. Second run was cancelled because the tracker would not lock. Third run partially successful. Mount hunt causes tracker to lose lock.
3/4/71	261A	Dummy launch. Airborne laser.	Pointing accuracy $\pm$ 1/2 mil at 8000 feet. Spot left target at launch. Tracker unlocked and was manually returned within two seconds. Launch at 4800 feet.

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Table B-2 Continued

Date	Test No.	Plan	Comments
3/5/71	266	Launch with high explosive warhead against stationary truck. Airborne laser illuminator. Guided rocket.	Cancelled Run #1 because airspeed too high. Run #2 cancelled because of high winds. Run #3 launch at 6000 feet. One foot right of spot 6 feet from target. Mount had not settled down after a heading change before the missile was launched. Tracker retained lock until target obscured by missile smoke. Manual track was regained at 6.25 seconds.
3/8/71	267	Pointing accuracy test. Airborne laser.	Four runs completed. Tracker did not lose lock when maximum 4 degree steps were applied.
3/8/71	267	Pointing accuracy test. Airborne laser.	Five runs OK except for minor problem on Run #3. Did not recur. Lock maintained.
3/9/71	268	Offset target run to evaluate smoke obscuration problem.	Laser problem during second run. Three other runs were satisfactory.
3/10/71	269	Guided missile launch with inert warhead. Airborne illuminator. Missile TLM. Target board for missile. Truck for contrast tracker.	First run dry. Launched at 7500 feet on the second run. TV blanked out at firing for 7 seconds. Contrast tracker lost lock when operator assumed manual control. Impact was 130' short, 6' left. TLM shows seeker locked on spot. No smoke problem.
3/12/71	270	Dummy LARS II launch.	Cancelled because of laser problems.
3/15/71	270	Dummy LARS II to check laser pointing with 1.5 degree offset to minimize smoke obscuration.	Cancelled because of high winds, poor TV, aircraft problem and RFI.

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Table B-2 Continued

Date	Test No.	Plan	Comments
3/16/71	270	Dummy LARS II to check laser pointing with 1.5 degree offset to minimize smoke obscuration. Target board.	Excessive mount movement at launch. Contrast tracker lost lock after launch when smoke obscured target. Laser pointing OK. Offset only .5 degrees rather than 1.5 degrees.
3/17/71	271	LARS II pad firing to determine cause of helicopter yaw.	Missile exhaust gases hit aircraft frame when missile exits tube.
3/18/71	272	LARS II with shaped charge warhead to evaluate contrast tracker.	Cancelled because of high gusty winds.
3/19/71	272	LARS II with shaped charge warhead to evaluate contrast tracker. Ground illuminator. Stationary tank target.	Launched at 6000'. Impact 4' right, 1-1/2' up. The 1 degree offset of missile launch heading eliminated smoke problem. Tracker maintained lock but did shift track point. 20 knot crosswinds. Five degree yaw observed at launch.
3/24/71	-	Ground launch to evaluate deflection plates.	Aircraft still shows excessive yaw.
4/1/71	-	Dummy launch with aircraft on turntable to evaluate deflection plates.	Yaw is still excessive.
4/2/71	-	Dummy launch with aircraft on turntable to evaluate deflection plates.	Some improvement noted.
4/5/71	-	Airborne launch of dummy LARS while mount is locked in position.	Cancelled because of aircraft tip brakes and yaw rate servo problems.

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Table B-2 Continued

Date	Test No.	Plan	Comments
4/5/71	-	Airborne launch of dummy LARS while mount is locked in position.	Yaw is about 1 degree which is normal hunting.
4/6/71	-	Airborne launch of dummy LARS to observe effects of yaw.	Missile did not fire. Loose firing contact repaired.
4/6/71	-	Airborne launch of dummy LARS to observe effects of yaw.	Contrast tracker shifted lock points at launch. Shift also occurred 10 seconds later when a turn was commanded.
4/7/71	-	Airborne launch of dummy LARS to evaluate contrast tracker.	Tracker worked well on first run. Would not hold lock on second run. Test cancelled.
4/20/71	-	Airborne and pad launches.	Cancelled because of mount gear problems.
4/28/71	-	Pad launch to check yaw.	Excessive yaw. Tracker remained locked.
4/29/71	-	Check flight to monitor mount with weights removed.	Excessive mount vibration in pan and tilt. Tracker maintained lock.
4/29/71	-	Pad launch to check yaw.	Excessive yaw. Tracker not working.
4/30/71	-	Pad launch to check yaw.	Excessive yaw. Tracker unlocked because of smoke.
5/4/71	-	Pad firing to check yaw.	Missile did not fire.
5/4/71	-	Check flight to evaluate mount vibrations. 50 lb. tube added for damping.	Mount not working properly. Bad micro switch replaced. Tracker locked and held.

Table B-2 Continued

Date	Test No.	Plan	Comments
5/5/71	-	Pad firing to evaluate deflectors. Check flight to evaluate mount vibrations.	Pad firing completed. Check flight cancelled in flight because of aircraft problems. Mount operation was unsatisfactory.
5/7/71	-	Pad firing to evaluate deflectors.	A .5 mil deflection was observed.
5/7/71	-	Check flight to observe mount vibrations.	Mount OK. Tracker maintained lock.
5/10/71	274	LARS II launch to evaluate mount performance and laser pointing. No guidance.	First run cancelled because shadows in target area caused tracker to lose lock. Second run was cancelled when the missile did not fire.
5/11/71	274	LARS II launch to evaluate mount performance and laser pointing. No guidance.	First run cancelled because aircraft was too close to target. Launched on 2nd run at 6200'. Tracker maintained lock but mount vibration caused some laser pointing problems.
5/12/71	275	LARS launch with TLM warhead.	Cancelled because pan axis vibration was causing lock on problems.
5/12/71	275	LARS launch with TLM warhead.	Missile TLM inoperative. Laser pointing excellent.
5/12/71	275	LARS launch with TLM warhead.	Cancelled because of TV and tracker lock problems.
5/24/71	275	LARS launch with TLM warhead.	Cancelled because of an aircraft command problem.
5/25/71	275	LARS launch with TLM warhead.	Cancelled both runs because of laser problems.
5/25/71	275	LARS launch with TLM warhead.	Cancelled because of laser problems.

Table B-2 Continued

Date	Test No.	Plan	Comments
9/9/71	-	Check flight to verify flight capability of DS-1725.	The mount, TV camera, contrast tracker and mount camera were exercised and performance was satisfactory.
9/20/71	330	Launch preparations.	Boresighting and all ground tests were completed.
9/21/71	330	Launch preparations.	Check flight completed. Tip rate problem occurred. The mount became inoperative in flight. The batteries were run down.
9/22/71	332	Launch preparations.	Aborted in flight because of excessive TV jitter at full zoom caused by mount motion. A blown fuse caused by a modification stopped all mount movement.
9/23/71	332	Launch preparations.	Mount was replaced and balanced. Flight was aborted because of excessive jitter.
9/24/71	332A	Check Flight	Improvement noted in tilt axis. Pan axis vibrations are still excessive.
9/27/71	355	Launch	Aborted when excessive pan vibrations and telemetry problems could not be fixed during alloted range time.
9/27/71	-	Check flight to evaluate results of ground work.	Flight completed but the pan oscillations were bad. Mount control was lost.
10/1/71	351	Evaluate launch readiness.	Three flights were completed. Oscillation improved to 2.0 mils at 2 cycles. Does not meet launch requirements.

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Table B-2 Continued

Date	Test No.	Plan	Comments
10/4/71	-	Evaluation Flight	Horizontal oscillations were noticed on first run. Mount balance did not change vibration but lock on occurred at 7000' vs 6000'. The laser TV generator failed on the third run.
10/5/71	-	Evaluation Flight	Laser pointing now estimated to be 0.5 mils in tilt and 1.0 mils in pan.
10/6/71	-	Evaluation Flight	Aborted because of problems in the ground station.
10/7/71	-	Evaluation Flight	Aborted when a compressor problem developed in flight.
10/8/71	-	Evaluation Flight	Two runs were completed. Laser pointing was 0.7 mils in pan and 0.2 in tilt.
10/8/71	352	Unguided missile launch.	Cancelled to work on tilt control problem.
10/12/71	-	Check flight to evaluate tracker performance.	Two flights were completed and results confirm launch readiness.
10/12/71	352	Launch an unguided missile with Mark I warhead and inert fuse.	Launch occurred at 5800'. No smoke of flame was visible on TV. Tracker held lock at all times.
10/13/71	354	Launch a guided missile equipped with a telemetry warhead at a target board.	First run aborted because erratic telemetry indications were being received from the launcher. Second run aborted for the same reason and there was no telemetry in the van. Mount control was lost on the return flight. Dead batteries and a loose telemetry connector were the causes.

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Table B-2 Continued

Date	Test No.	Plan	Comments
10/14/71	354	Launch a guided missile equipped with a telemetry warhead at a target board.	Test was delayed because all base power was lost. Two check runs were made. Contrast tracker difficulties and low signal strength readings were observed. Launch occurred on the third run at 4800'. Impact occurred 10' high and 10' right from center of target. This launch range did not provide enough time for the guidance system to correct for launch transients.
10/15/71	355	Launch missile equipped with a live warhead at a stationary truck.	Aborted because of high winds and dust.
10/18/71	-	Evaluation Flight	TV jitter was excessive and lock could not be maintained.
10/19/71	-	Evaluation Flight	Aborted when TV failed.
10/20/71	-	Evaluation Flight	Target board laser camera failed. TV jitter is still excessive. New gyros did not improve performance.
10/21/71	-	Evaluation Flight	Adjustments eliminated jitter.
10/26/71	-	Evaluation Flight	Oscillations in pan axis prevented tracker lock. Pointing accuracy is 2.0 mils.
10/27/71	-	Evaluation Flight	Pan oscillation is excessive.

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Table B-2 Continued

Date	Test No.	Plan	Comments
10/28/71	355	Launch guided missile with telemetry warhead at stationary tank. GCA Gryos on North American Mount.	Cancelled because of snow.
10/29/71	-	Check flight for operational evaluation	The mount lost tilt control. Problem was caused by a loose plug-in-board.
10/29/71	355	Launch guided missile with telemetry warhead at stationary tank. GCA Gyros on North American Mount.	After two check runs were made to confirm operation launch occurred at 6000'. Impact was 1650' short and 500' left. Later evaluation confirmed that the laser was tracking spurious reflections.
11/1/71	-	Evaluation Flight	Cancelled because mount work could not be completed on time.
11/2/71	353	Captive flight to evaluate pointing.	Two runs were completed. Pointing was 1.3 mils and boresighting is required.
11/2/71	352A	Launch an unguided missile.	Launch occurred at 5500' on the second run. Oscillations were observed in pan axis. Pointing accuracy was estimated to be 1.3 mils. No mount movement and tracker remained locked.
11/3/71	353A	Captive flight with guided missile.	Mount performance was excellent: 0.6 mils in pan and 0.2 mils in tilt. This test also confirmed that the seeker will track "back-scatter".

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Table B-2 Continued

Date	Test No.	Plan	Comments
11/3/71	352B	Launch an unguided missile.	Missile was launched at 6,000 feet. The laser spot remained on the tank turret.
11/3/71	356	Launch a guided missile with telemetry warhead at stationary tank.	Cancelled to install a modification to indicate "backscatter".
11/4/71	356	Launch a guided missile with telemetry warhead at a stationary tank.	Missile hit laser spot.
11/4/71	357	Launch a guided missile at moving tank. Shaped charge warhead.	Missile hit laser spot. Warhead did not explode.

TABLE B-3 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR LARS II (Night)

Date	Test No.	Plan	Comments
9/7/71	-	Evaluation Flight	Satisfactory
9/10/71	321	Launch an unguided missile to evaluate flame effects on LLLTV.	Cancelled flight when TV transmitter failed.
9/11/71	322	Launch a dummy rocket to evaluate flame effects on LLLTV.	TV microphonics prevented tracker lock on the target. Flame period was less than expected.

Table B-3 Continued

Date	Test No.	Plan	Comments
10/4/71	-	Evaluation Flight	No vibrations. Could not lock on target because of a TV problem. Second run aborted because tilt control was lost. Third flight .75 mils pointing accuracy.
10/5/71	-	Evaluation Flight	Downrange laser failed. Mount TV became erratic during flight. Pan oscillation was not present.
10/6/71	-	Evaluation Flight	Laser pointing accuracy is .3 mils. The modification to add a delay circuit to the contrast tracker did not work.
10/7/71	351A	Evaluation Flight	Flight was aborted when tilt control was lost.
10/13/71	-	Evaluation Flight	Cancelled because of a problem in the command decoder.
10/14/71	-	Evaluation Flight	The ILS laser was used and ranging information was good. A 2 cycle oscillation was detected.
10/15/71	-	Evaluation Flight	Cancelled because the TV failed.
10/18/71	-	Evaluation Flight	Cancelled for gyro repairs.
10/19/71	-	Evaluation Flight	Cancelled when telemetry and gyro problems occurred during check out.
10/20/71	-	Evaluation flight against a 20' x 20' target board.	Two flights consisting of nine runs were completed. Average pointing accuracy was 1.3 mils.

Table B-3 Continued

Date	Test No.	Plan	Comments
10/21/71	-	Evaluation Flight	A ground station command control problem delayed lift-off. Three runs were completed and average pointing accuracy was 0.8 mils.
10/27/71	-	Evaluation Flight	Cancelled to complete mount work.
10/28/71	-	Evaluation Flight	LLLTV performance was poor.
10/28/71	-	LLLTV Demonstration.	Cancelled when LLLTV intensifier failed.
10/28/71	-	LLLTV Demonstration.	Targets were detected.
11/9/71	-	Evaluation Flight	Cancelled after take-off because the TV failed. A connector was repaired after the flight.
11/10/71	-	Evaluation Flight	Two check runs show mount instability.
11/10/71	323	Launch a dummy missile at night.	Cancelled because of poor mount performance.
11/10/71	-	Night Evaluation Flight	Excessive jitter was still present. LLLTV required focus adjustment.
11/11/71	-	Evaluation flight to check new camera mount.	Two runs were made and the jitter appears to have been reduced.
11/12/71	323	Launch a dummy missile with warhead at night.	The laser illuminator failed on the first run. Tracker lock could not be maintained on second run. On the third run the drone drifted off course. Launch occurred on the fourth run. The tracker lost lock when motor sparks "bloomed" the TV.

Table B-3 Continued

Date	Test No.	Plan	Comments
11/15/71	-	Evaluation Flight	Flight was delayed because of a command transmitter failure. In flight, excessive picture motion was observed.
11/15/71	323A	Launch a dummy missile at night.	Cancelled because the check flight showed that the TV picture was bad and the tracker would not hold lock.
11/16/71	323A	Launch a dummy missile at night.	The tracker would not lock on first run because of poor target contrast. Missile was launched on second run. The tracker momentarily lost lock but regained lock on the same point after the inhibit function was completed. A third run was cancelled when mount control was lost. A broken resistor lead was repaired after the flight.
11/17/71	-	Day Evaluation Flight	Satisfactory
11/17/71	323B	Unguided missile launch.	Tracker would lock on target and the target could not be recognized on airborne TV. The TV illuminator failed on the second run. Lock could not be maintained on third run.
1/21/72	950	Evaluation Flight	Flight cancelled when telemetry failed.
1/24/72	951	Evaluation Flight	Cancelled in flight when vibration occurred in pan axis.

Table B-3 Continued

Date	Test No.	Plan	Comments
1/25/72	952	Evaluate Mount	Satisfactory
1/25/72	953	Evaluate LLLTV	Several satisfactory passes and then camera control box broke off the mount.
1/26/72	954	Evaluate LLLTV	Cancelled inflight when TV power and mount control was lost.
1/27/72	955	Evaluate Tracker	Tracker did not hold lock.
1/27/72	425	Unguided missile launch.	Tracker held lock.
1/27/72	426	Unguided missile launch.	Excessive yaw at launch. Tracker unlocked.
1/28/72	427	Unguided missile launch.	Cancelled in flight when TV failed.
1/28/72	427	Unguided missile launch.	Excellent tracking. Lock maintained.
1/28/72	428	Guided missile launch. Stationary tank target.	Cancelled in flight because of LLLTV problems.
1/31/72	428	Guided missile launch. Stationary tank target.	Tracker lost lock at launch. Missile flew over the target. Launched on fifth pass.
2/2/72	429	Guided missile launch. Stationary tank target.	Tracker lost lock. Missile missed target.

APPENDIX C

FLIGHT TEST DATA FOR LARS

(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

SECTION C-1
LARS I TEST REPORTS

CHECK FLIGHT
Flight No. 1 Test No. 31
11 March 1970

(C) This test was conducted to verify the operational capability of the system. The aircraft was flown at a 20 knot airspeed at an altitude of 1000 feet. All systems operated satisfactorily on the first pass. The second pass was cancelled because of high winds in the target area. The system was declared ready to support an unguided missile launch. Flight time was sixteen minutes.

Weather Conditions

Barometric Pressure: 26.65" Hg
Temperature. 60°F
Wind, Surface: 18 to 40 knots from 240°T

UNGUIDED MISSILE LAUNCH
Flight No. 2 Test No. 31A
11 March 1970

(C) This test was conducted to determine helicopter and missile interactions by launching an unguided missile with an inert warhead at a target board. The target board was used for aiming practice only since the missile was unguided. Ground speed was 18 knots and flight altitude was 1000 feet. A fuse in the ground portion of the DAME system blew on the first pass at the target. The fuse was replaced and the missile was successfully launched on the second pass. Flight time was twenty-three minutes.

Weather Conditions

Barometric Pressure: 26.64" Hg
Temperature: 60°F
Wind, Surface: 6 knots from 300°T

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GUIDED MISSILE LAUNCH
Flight No. 3 Test No. 32
12 March 1970

(C) This test was scheduled to check all systems by launching a guided missile with an inert warhead. The target was a stationary truck, helicopter ground speed was to be minimum safe and flight altitude to be 1000 feet at launch time. Lift-off was at 0911 but the flight was cancelled because of severe interference on the telemetry link. Flight time was seventeen minutes.

Weather Conditions

Barometric Pressure: 26.84" Hg
Temperature: 57°F
Wind, Surface: 8 knots from 290° T

INVESTIGATE RFI
Flight No. 4 Test No. 32
12 March 1970

(C) This test was conducted to investigate the source and type of interference observed on the previous flight. Various ground and airborne instrumentation configurations were switched off and on, but the interference remained. Checks indicate that the interference did not originate at Nellis. Monitoring agencies were called in to determine the source. Flight time was twenty minutes.

Weather Conditions

Barometric Pressure: 26.84" Hg
Temperature: 57°F
Wind, Surface: 8 knots from 290° T

GUIDED MISSILE LAUNCH
Flight No. 5 Test No. 32
13 March 1970

(C) This test was conducted to launch a guided missile at a stationary truck target for a complete system check out. Approach to the target was started at a range of 10,000 feet and was made at a ground speed of 31 knots and an altitude of 931 feet. The missile was launched at a slant range of approximately 5,000 feet, impact was 504 feet short and 216 feet to the right of the target. Post flight analysis revealed that missile roll control was lost. This problem was corrected by a design change to the external configuration of the missile. Flight time was thirty-five minutes.

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Weather Conditions

Barometric Pressure: 26.98" Hg
Temperature: 52°F
Wind, Surface: 3 knots from 0°T
100' 2 knots from 190°T

GUIDED MISSILE LAUNCH
Flight No. 6 Test No. 32A
16 March 1970

(C)This test was scheduled to launch a guided missile with an inert warhead. The target was an aluminum reflector mounted on the hood of a stationary truck. All systems were boresighted prior to the flight. Target approach was made at a ground speed of 20 knots, altitude 1000 feet. The launch was cancelled when severe telemetry interference was encountered. The helicopter was returned to the pad where a hard landing damaged a fuel line. Flight time was seventeen minutes.

Weather Conditions

Barometric Pressure: 26.30" Hg
Temperature: 70°F
Wind, Surface: 2 knots from 0°T

INVESTIGATE RFI
Flight No. 7 Test No. 32A
17 March 1970

(C)This test was conducted to determine the source of the interference that caused the loss of telemetry on the previous flight. Investigation revealed a problem in the telemetry transmitter on board the helicopter. After the flight it was replaced and another check flight was scheduled. Flight time was ten minutes.

Weather Conditions

Barometric Pressure: 26.58" Hg
Temperature: 65°F
Wind, Surface: 20 - 30 knots from 330°T

VERIFY TELEMETRY OPERATION
Flight No. 8 Test No. 32A
17 March 1970

(C)This test was conducted to check out the telemetry system. Three passes were made at the target area from an altitude of 600 feet. Ground speed varied from 5 to 40 knots. No problems were encountered. Flight time was forty-one minutes.

Weather Conditions

Barometric Pressure: 26.57" Hg
Temperature: 65°F
Wind, Surface: 12 knots from 320° T

OBTAIN SIGNAL STRENGTH DATA
Flight No. 9 Test No. 61
7 April 1970

(C)This test was conducted to obtain signal strength data from a laser illuminated 3' x 3' aluminum target. The missile was mounted in the launch tube and the signal from the target was detected by the seeker head and transmitted to the ground station. The laser illuminator was located 1500 feet from the target. Flight altitude was 1000 feet and ground speed was 25 knots. Five passes were made at the target. Winds in the target area were too high to collect all required data. The target range used to obtain signal strength data is shown in Figure C1. Flight time was fifty-three minutes.

Weather Conditions

Barometric Pressure: 26.57" Hg
Temperature: 65°F
Wind, Surface: Calm

OBTAIN SIGNAL STRENGTH DATA
Flight No. 10 Test No. 62
7 April 1970

(C)This test was conducted to obtain signal strength measurements from a laser illuminated olive drab truck target while the missile is mounted on the helicopter. The laser illuminator was located on the ground 1,500 feet from the truck. Three passes were completed at an altitude of 1000 feet and ground speed varied from 25 to 35 knots. On all three passes, the seeker head locked on the reflected signal at a range of 3,000 feet. Flight time was forty-three minutes.

Weather Conditions

Barometric Pressure: 26.65" Hg
Temperature: 73° F
Wind, Surface: 5 - knots from 310° T

OBTAIN SIGNAL STRENGTH DATA
Flight No. 11 Test No. 62
8 April 1970

(C) This test was conducted to obtain signal strength data from an olive drab truck target with the laser illuminator located on the ground 5,000 feet from the target. Three passes were completed from an altitude of 1,000 feet. Ground speed was 26 knots. One additional pass was made at the 3' x 3' aluminum reflector. Adequate signal levels were observed on all passes. Flight time was sixty-two minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 72° F
Wind, Surface: 6 knots from 300° T

OBTAIN SIGNAL STRENGTH DATA
Flight No. 12 Test No. 63
8 April 1970

(C) This test was conducted to obtain additional signal strength data from the olive drab truck target with the illuminator located on the ground, 5,000 feet from the truck. Three passes at the target were completed from an altitude of 1,000 feet and ground speed was 26 knots. The seeker locked on the reflected signal from the truck at a slant range of 8,000 feet. Another pass was made using a 3' x 3' aluminum sheet as a target, and the seeker locked on at a range of 10,000 feet. Flight time was fifty-eight minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 72° F
Wind, Surface: 6 knots from 330° T

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LARS TARGET GRID

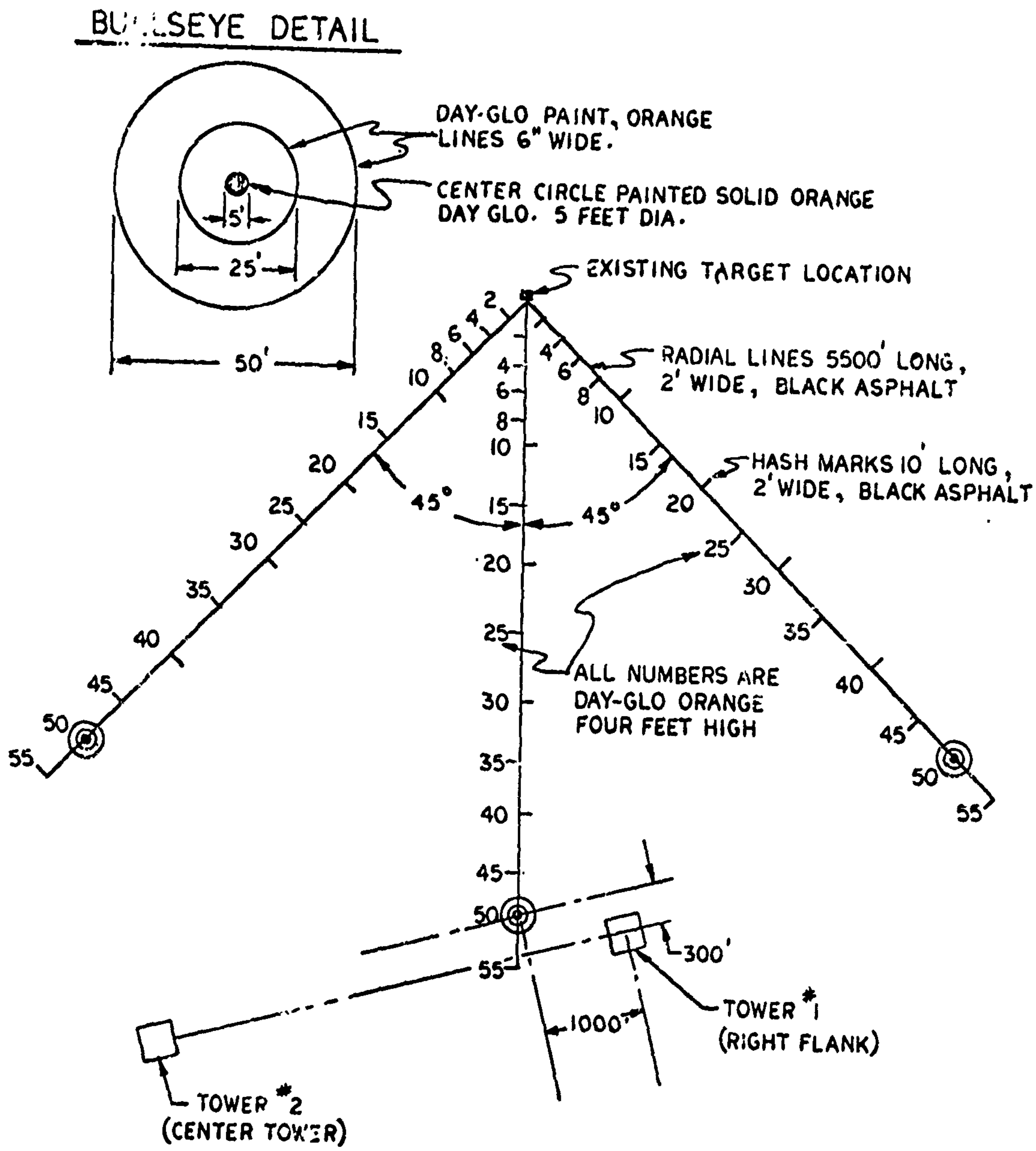

Figure C-1

CONFIDENTIAL
(This page is UNCLASSIFIED)

UNGUIDED MISSILE LAUNCH
Flight No. 13 Test No. 31A
10 April 1970

(C)This test was conducted to determine helicopter reaction when a missile is launched. The missile was unguided and carried an inert warhead. A target board was used for aiming practice. Flight altitude was 1,000 feet, ground speed was 20 knots, and approach to the target was started at approximately 10,000 feet. Three passes were made to determine the proper helicopter location at launch time. The missile was fired on the fourth pass when the helicopter was fifty feet to the right of the run in line and approximately 5,000 feet from the target. No adverse helicopter reactions were observed. Flight time was forty-two minutes.

Weather Conditions

Barometric Pressure: 26.76" Hg
Temperature: 71°F
Wind, Surface: 4 knots from 270° T

OBTAIN SIGNAL STRENGTH DATA
Flight No. 14 Test No. 64
10 April 1970

(C) This test was conducted to obtain signal strength data from the olive drab truck target when the laser illuminator is located fifty feet from the target. Six passes were successfully completed from a flight altitude of 1,000 feet and using a ground speed of 20 knots. Flight time was sixty-nine minutes.

Weather Conditions

Barometric Pressure: 26.67" Hg
Temperature: 80°F
Wind, Surface: 6 knots from 300° T

GUIDED MISSILE LAUNCH
Flight No. 15 Test No. 31B
15 April 1970

(C) This test was conducted to determine the ability of the missile to hit an aluminum panel mounted on the fender of a truck. The laser illuminator was located on the ground. The missile contained a high explosive warhead and an inert fuse. Flight altitude was 1,000 feet, ground speed was 20 knots, and approach to the target was started at 10,000 feet. The missile was launched

when the helicopter was at a slant range of 4,800 feet from the target. Impact was one foot low. One previous attempt was made to launch this missile. Total flight time was eighty-seven minutes.

Weather Conditions

Barometric Pressure: 26.46" Hg
Temperature: 65° F
Wind, Surface: 7 knots from 030° T

GUIDED MISSILE LAUNCH
Flight No. 16 Test No. 39
17 April 1970

(C) This test was conducted to obtain the impact location of a LARS missile. The guided missile carried a live warhead and a MK 423 fuse. The ground laser illuminator was located 500 feet from the target and pointed at the hood of the truck target. Flight altitude was 1,000 feet and ground speed was 20 knots. The missile was launched at a slant range of 5,000 feet. Some mount movement was observed at launch time. Impact occurred 2,000 feet short because the missile lost roll control. This problem was corrected on later missiles by a change in the external configuration of the missile. A previous attempt to launch this missile was cancelled when the TV failed shortly after launch. Flight time was eighteen minutes.

Weather Conditions

Barometric Pressure: 26.79" Hg
Temperature: 67° F
Wind, Surface: 32 knots from 300° T

EVALUATE TRACKER PERFORMANCE
Flight No. 17 Test No. -
9 October 1970

(C) This test was conducted to evaluate the tracking performance of the contrast tracker. A dummy missile was in the launcher during this test. Two passes were made at a truck target located on the old railroad bed. Two more passes were made at a 20' x 20' target board. The contrast tracker lost track every time the airspeed was changed. Flight altitude was 500 feet, ground speeds varied from minimum safe to 30 knots, and data were collected at ranges of 8,000, 6,000, 4,000 and 2,000 feet. Flight time was fifty-eight minutes.

EVALUATE TRACKER PERFORMANCE
Flight No. 18 Test No. -
9 October 1970

(C) This test was conducted to evaluate the performance of the contrast tracker with no missile in the launch tube. Two passes were made at a truck target located on the old railroad bed. Two more passes were made at a 20' x 20' target board. The contrast tracker lost track when the airspeed was changed. Flight altitude was 500 feet, ground speed varied from a minimum safe to 30 knots, and data were collected at ranges of 8,000, 6,000, 4,000 and 2,000 feet. Flight time was fifty minutes.

EVALUATE TRACKER PERFORMANCE
Flight No. 19 Test No. -
14 October 1970

(C) This test was conducted to evaluate the contrast tracker performance at various TV focal lengths. Flight altitude was 500 feet. Ground speed varied from 20 to 40 knots. Passes were made at target boards and towers with the field of view at 2.3 degrees, 4.6 degrees and 10 degrees. The 16 mm camera was operated at data collection points. At full zoom, 2.3 degrees, perturbations of the mount caused by sudden changes in the airspeed caused the tracker to lose lock. Activation of the firing circuit also caused the tracker to lose lock. These problems did not occur when the television field of view was 4.6 degrees or 10 degrees. Because of a boresight error, the target was not in the field of view of the camera. Flight time was forty-eight minutes.

Weather Conditions

Barometric Pressure: 26.70" Hg
Temperature: 78°F
Wind, Surface: 4 knots, variable

UNGUIDED MISSILE LAUNCH
Flight No. 20 Test No. 31C
21 October 1970

(C) This test was conducted to determine the helicopter reaction when the LARS is launched. The missile was unguided and carried an inert warhead. A 20' x 20' target board was used as a practice aimpoint. After a successful dry run to verify the operation of all systems, the missile was launched on the second approach to the target. Flight altitude was 600 feet and ground speed was 20 knots. Target contrast was poor because of hazy weather conditions. The contrast tracker locked on the target at a slant range of 7,000

feet. The missile was launched when the helicopter was approximately 5,500 feet from the target. The TV field of view was 4.6 degrees. When the missile was launched the mount pitched down at a rate of 6.9 degrees/second. During this down movement, smoke from the missile obscured the target for 0.5 second. These two situations caused the contrast tracker to lose lock. Flight time was twenty-three minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 60° F
Wind, Surface: Calm

OBTAIN SIGNAL STRENGTH DATA
Flight No. 21 Test No. 66
26 October 1970

(C) This test was conducted to obtain signal strength data from the missile seeker head when the laser illuminator was located at various distances from a ground target. Flight altitude was 1,000 feet and the ground speed was held to a safe minimum at data collection points. Results are shown in Table C-1. A signal 5 db above threshold is required for correct seeker operation. At one point the mount was moved ±8 degrees in azimuth to determine the field of view of the seeker head. Results of this test are shown in Figure C2. Flight time was sixty-two minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 62° F
Wind, Surface: 10 - 25 knots from 330° T

TABLE C-1 (Title Unclassified
Signal Strength vs Range Table Confidential)
Test 66 26 October 1970

Pass	Laser Range (ft)	Seeker Range (ft)	Outerloop AGC	Signal Strength Above Threshold
1	ABORT BECAUSE OF HIGH WIND			
2	7000	5000	2.0V	27 dB
3	7000	8000	2.28	22
		7000	2.22	23
		6000	2.10	25

TABLE C-1 Continued

Pass	Laser Range (ft)	Seeker Range (ft)	Outerloop AGC	Signal Strength Above Threshold
		5000	1.98	28
		4000	1.9	30
4	5000	7000	2.3	21.5
		6000	2.1	25
		5000	1.95	29
		4000	1.8	33
5	4000	9000	2.8	16
		8000	2.5	18
		7000	2.3	21.5
		5000	2.0	27.0
		4000	1.85	32

GUIDED MISSILE LAUNCH
Flight No. 22 Test No. 67
27 October 1970

(C) This test was conducted to determine the impact location of a LARS missile. The ground laser illuminator was located 500 feet from a 20' x 20' target board and offset 30° from the run in line. The missile was instrumented with a telemetry system. Two passes were made to verify system operation. Launch occurred on the third pass when the helicopter was at a slant range of 5,100 feet from the target. Flight altitude was 600 feet and ground speed was 5 knots. Signal strength was 33 db above threshold at launch time. The mount pitched up 1.2 degrees at a 9.5 degree/second rate when the missile was launched. Some smoke was visible on the TV screen. The contrast tracker lost lock for one second and then re-acquired track on the other side of the target. Impact occurred three feet low and one foot to the right of the laser spot. Flight time was forty-two minutes.

Weather Conditions

Barometric Pressure: 26.78"Hg
Temperature: 68°F
Wind, Surface: 6 - 10 knots from 0°T

CONFIDENTIAL

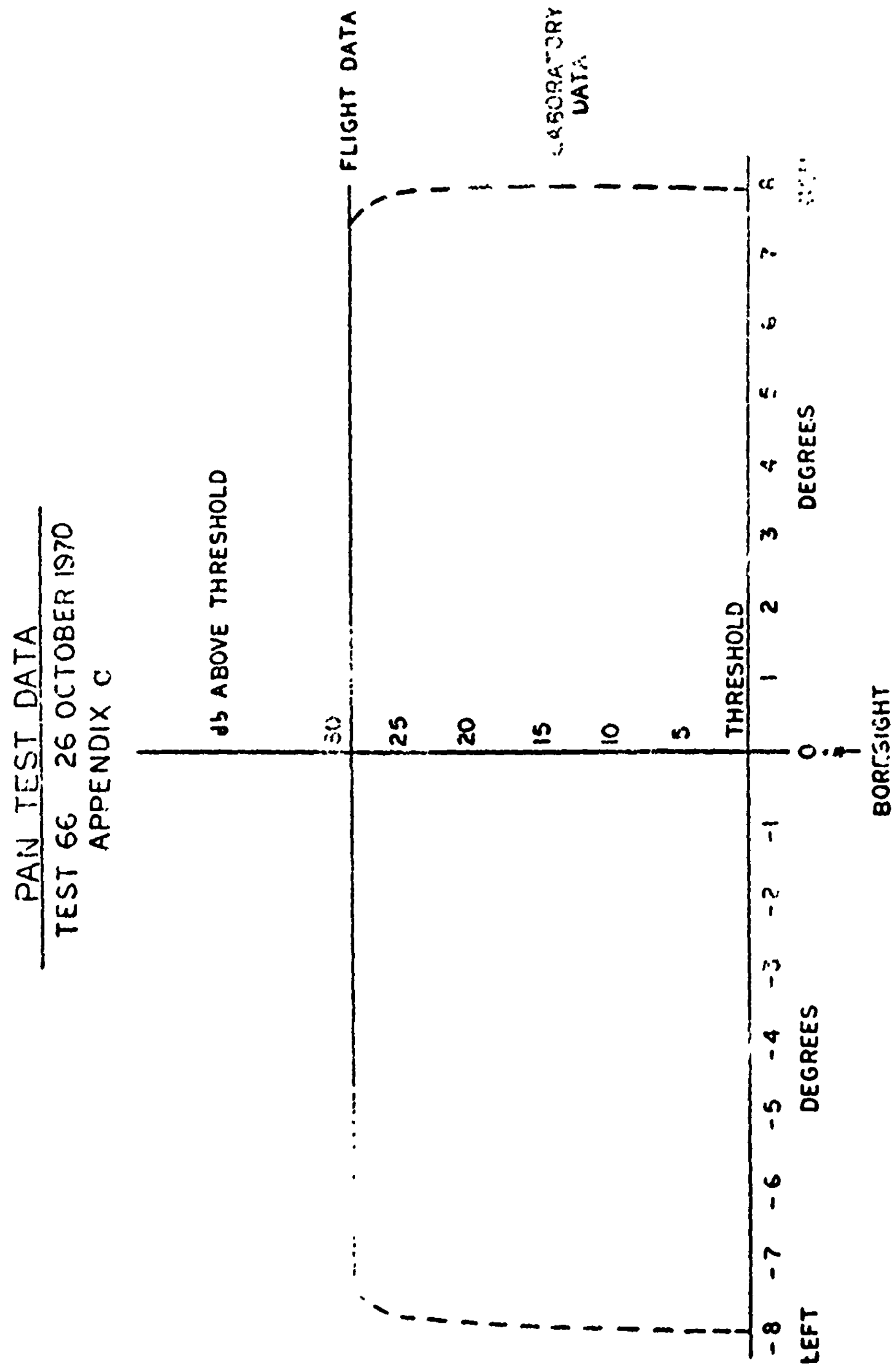

Figure C-2

CONFIDENTIAL
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GUIDED MISSILE LAUNCH
Flight No. 23 Test No. 68
3 November 1970

(C)This test was conducted to obtain the impact location of a LARS missile. The target was a dull blue truck and the laser illuminator was pointed at the hood. The illuminator was located 500 feet from the target and offset 30° from the run in line. The missile was guided and carried a telemetry instrumentation system. Flight altitude was 600 feet and the ground speed was 5 knots. The missile was launched when the helicopter was 5,200 feet from the target. Signal strength was 25 db above threshold at launch and error voltages were near zero. At launch, the mount pitched up 1.7° and the tracker lost lock. Impact was 6 feet left and 4 feet low of the aimpoint. One previous attempt to launch this missile was cancelled because of darkness. Flight time was thirty-six minutes.

Weather Conditions

Barometric Pressure: 26.88" Hg
Temperature: 62°F
Wind, Surface: 20 knots from 108°T

GUIDED MISSILE LAUNCH
Flight No. 24 Test No. 68A
5 November 1970

(C) This test was conducted for the purpose of obtaining the impact location of a LARS missile. The target was scheduled to be a moving truck and the laser illuminator was mounted on a bracket attached to the truck. The steering actuator on the truck broke and a decision was made to fire at a stationary truck. The missile was guided and carried a telemetry instrumentation system. Flight altitude was 1,200 feet and ground speed was 5 knots. The TV lens was set at 3/4 zoom because contrast tracker difficulties were observed when the lens was set at full zoom. The missile was launched when the helicopter was at a range of 6,500 feet from the target. Impact was eleven feet low and exactly on the vertical line through the center of the aimpoint. The mount pitched up at launch. One previous attempt to launch this missile was cancelled because of problems with the target. Flight time was eighty-two minutes.

Weather Conditions

Barometric Pressure: 26.75" Hg
Temperature: 70°F
Wind, Surface: 25 knots from 180°T

SECTION C-2
LARS II (DAY) TEST REPORT

HELICOPTER POINTING
Flight No. 1 Test No. 230
18 November 1970

(C) This test was conducted to determine the ability of the helicopter control system to point the missile at the target while the tracking mount is locked in azimuth. Azimuth tracking accuracy to be determined by analyzing 16 mm camera film and video tape. The TV lens was set at full zoom. During the first two passes the target could not be maintained in the field of view because of high, gusty winds. The data acquired on the third pass show that the average pointing excursions were 11 mils left and 9 mils right. Peak excursions to 40 mils right and 85 mils left were observed. Flight altitude was 500 feet and a minimum safe ground speed was maintained at the data collection points. Range to the target varied between 4,000 and 5,000 feet. Flight time was forty minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: Not available
Wind, Surface: 5 - 35 knots from 270° T to 330° T

HELICOPTER POINTING
Flight No. 2 Test No. 230A
18 November 1970

(C) This test was conducted to obtain additional helicopter pointing accuracy data. The tracking mount was locked in azimuth and the helicopter changed heading to keep the target in the center of the 16 mm camera and TV systems. The TV lens was at a 3/4 zoom. Flight altitude was 500 feet and ground speed varied from minimum safe to 20 knots. Data were recorded when airspeed and heading changes were made. Four passes were completed and the accuracy was comparable to the previous test. Flight time was eighteen minutes.

LAUNCHER TEMPERATURE DATA
Flight No. 3 Test No. 285
18 February 1971

(C) This test was conducted to determine the effect of the engine exhaust on the launcher tube. Temperature decals were attached to the launcher tube.

Flight altitude was 500 feet, ground speed was varied from 25 to 64 knots and many heading changes were made. The temperature of the launcher tube did not rise above 100 degrees during the flight. Flight time was twenty-six minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 43°F
Wind, Surface: 6 knots from 330° T

OBTAIN SIGNAL STRENGTH DATA
Flight No. 4 Test No. 260
18 February 1971

(C) This test was conducted to evaluate the signal strength data received by the LARS seeker head. The laser illuminator was located on the ground 500 feet from the target, and the missile-to-target range was varied from 10,000 to 5,000 feet. An aluminum plate was located in the center of the target board. Flight altitude was 1,000 feet and a minimum safe ground speed was maintained at the data collection points. On all runs the received signal levels were 25 db above threshold. The minimum required signal is 5 db above threshold. Additional pointing runs made during this flight show that the desired helicopter heading of ± 1° can be maintained at 10 knots in relatively still air. In gusty winds, airspeed must be 20 knots above maximum gusts to maintain the desired heading to an accuracy of ±1 degree. Flight time was fifty-three minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 43°F
Wind, Surface: 18 knots from 280° T

UNGUIDED MISSILE LAUNCH
Flight No. 5 Test No. 261
18 February 1971

(C) This test was conducted to determine the effect of an unguided missile launch on the helicopter, tracking mount and missile launcher. A truck in the LARS target area was used as a practice aimpoint. Flight altitude was 1,000 feet and the ground speed was 24 knots at launch time. The missile was launched at a slant range of 6,000 feet. The maximum helicopter yaw change noted at the time of launch was 3 degrees at a 3 degree/second rate. The

launcher pitched down approximately 1/2 degree at launch. Flight time was twenty-six minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 59°F
Wind, Surface: 4 knots from 330°T
1000' 4 knots from 296°T

GUIDED MISSILE LAUNCH
Flight No. 6 Test No. 262
24 February 1971

(C) This test was conducted to evaluate the flight characteristics of the LARS II missile carrying a telemetry instrumentation system. The guided missile target was a 20' x 20' target board with an aluminum plate mounted in the center. The laser illuminator was located on the ground, 500 feet in front of the target. Flight altitude was 1,000 feet and airspeed was 30 knots. The missile was launched when the helicopter was at a slant range of 6,500 feet from the target. The missile hit the center of the laser beam, which was one foot right and one-half foot below the center of the target. At launch, the helicopter yawed 4 degrees at a rate of 8 degrees/second. The tracking mount elevated 5 degrees at launch. One previous flight was made to launch this missile. Total flight time was sixty-five minutes.

Weather Conditions

Barometric Pressure: 26.71" Hg
Temperature: 56°F
Wind, Surface: light and variable
1000' 5 knots from 010°T

GUIDED MISSILE LAUNCH
Flight No. 7 Test No. 263
26 February 1971

(C) This test was conducted to verify the flight characteristics observed on Test 262 and to determine the capability of the shaped charge warhead. The target was an armored tank, illuminated by the laser located on the ground 500 feet from the target. Flight altitude was 1,000 feet and ground speed was 39 knots. Reflectivity of the tank was relatively low and a signal of only 12 db above threshold was observed. The seeker locked on and the missile was launched when the helicopter was 6,200 feet from the target. Impact was

within one foot of the laser spot location. The warhead did not explode. Maximum helicopter displacement in the yaw axis was 1 1/2 degrees to the right at a rate of 3 degrees/second. Flight time was thirty-nine minutes.

Weather Conditions

Barometric Pressure: 26.90" Hg
Temperature: 36° F
Wind, Surface: 10 - 18 knots from 330° T
1000' 13 knots from 320° T

AIRBORNE LASER POINTING
Flight No. 8 Test No. 286
2 March 1971

(C) This test was conducted to determine the ability of the helicopter/mount to keep the airborne laser pointing at a 12' x 12' target board. Flight altitude was 1,000 feet and ground speed was 26 knots. Laser spot movement was recorded on a downrange TV camera. The TV lens was set at the full zoom position. The contrast tracker was locked on the target. The maximum pointing error was .72 mil at 5,600 feet, 1.5 mils at 5,300 feet, .75 mil at 4,300 feet and 1.9 mils at 4,100 feet. Flight time was thirty-five minutes.

Weather Conditions

Barometric Pressure: 26.96" Hg
Temperature: 48° F
Wind, Surface: Calm

AIRBORNE LASER POINTING
Flight No. 9 Test No. 264
3 March 1971

(C) This test was conducted to evaluate the ability of the mount to point the airborne laser at the 20' x 20' target board, to collect signal strength from the missile, to verify the ability of the helicopter to maintain a heading with a yaw displacement of ±1 degree and to evaluate missile circuitry. Flight altitude was 1,000 feet and ground speed varied from 15 to 60 knots. The first run was satisfactory. On the second run the contrast tracker would not hold lock. On the third run mount oscillations increased and caused the contrast tracker to lose lock. The helicopter was able to maintain the desired heading, but the other test objectives were not met. Flight time was thirty minutes.

Weather Conditions

Barometric Pressure: 26.96" Hg
Temperature: 48°F
Wind, Surface: Calm

UNGUIDED MISSILE LAUNCH
Flight No. 10 Test No. 261A
4 March 1971

(C) This test was conducted to evaluate the ability of the mount to keep the laser pointed at the target when an unguided missile is launched. Flight altitude was 1,000 feet and ground speed was 15 knots. The contrast tracker locked on the target at a slant range of 11,500 feet. Laser target illumination was observed at 6,000 feet. Laser pointing dispersion was 0.5 mil at a range of 8,000 feet. The dispersion at a slant range of 4,000 feet was 1.0 mil. The missile was launched at a slant range of 4,800 feet. The laser spot left the target when the missile was fired because the contrast tracker lost lock. The spot was manually repositioned on the target two seconds after launch and the tracker was placed in the automatic track mode. Flight time was eighteen minutes.

Weather Conditions

Barometric Pressure: 26.53" Hg
Temperature: 51°F
Wind, Surface: Light and variable

GUIDED MISSILE LAUNCH
Flight No. 11 Test No. 266
5 March 1971

(C) This test was conducted to determine the impact location of a guided LARS II missile carrying a high explosive warhead. The airborne laser illuminator was pointed at a stationary truck target. Flight altitude was 1,000 feet and ground speed was 24 knots. The missile was launched when the helicopter was at a slant range of 6,000 feet from the target. The missile hit one foot right of the laser spot which was six feet from the target center. The mount was not stabilized after a heading change. The contrast tracker retained lock until smoke obscured the target at 1.25 seconds after launch. The target was obscured by smoke for a 0.9 second period. During this time the mount drifted 12 mils to the right of the target. The operator assumed manual control of the mount at 2.6 seconds and used this track mode until automatic track was regained at 6.25 seconds after firing. Flight time was thirty-three minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 42°F
Wind, Surface: 10 knots from 240° T
1,000' 15 knots from 320° T
1,500' 22 knots from 320° T
2,000' 26 knots from 320° T

AIRBORNE LASER POINTING
Flight No. 12 Test No. 267
8 March 1971

(C) This test was conducted to evaluate the ability of the contrast tracker to keep the airborne laser pointed at the target as various commands are executed by the helicopter. Flight altitude was 1,000 feet and ground speed was varied from 20 to 30 knots. The laser spot was maintained on the 12' x 12' target board when various commands were executed by the helicopter. Pointing ability was measured at ranges of 8,000, 6,000 and 4,000 feet. The contrast tracker maintained lock throughout the flight. Flight time was thirty minutes.

Weather Conditions

Barometric Pressure: 26.64" Hg
Temperature: 52°F
Wind, Surface: 4 knots from 300° T

AIRBORNE LASER POINTING
Flight No. 13 Test No. 267
8 March 1971

(C) This test was conducted to obtain additional pointing information. The airborne laser was mounted on the "Big U" mount. Flight altitude was 1,000 feet, ground speed was varied from 15 to 62 knots and various heading changes were executed by the helicopter. Five passes were completed. Data were acquired at ranges of 8,000, 6,000 and 4,000 feet. The spot was maintained on the 12' x 12' target board and the contrast tracker maintained lock on all passes except number 3. The mount was exercised from stop to stop and it performed well for the remaining runs. Flight time was sixty-three minutes.

Weather Conditions

Barometric Pressure: 26.65" Hg
Temperature: 62°F
Wind, Surface: 5 knots from 350°T

OFFSET TRACK EVALUATION
Flight No. 14 Test No. 268
9 March 1971

(C) This test was conducted to investigate the ability of the contrast tracker to maintain lock on one target board while the cursors are pointed on another target. The targets were separated by a distance of 550 feet The purpose of this offset track is to eliminate the smoke problem when the missile is launched. Flight altitude was 1,000 feet, ground speed was 25 knots, and range to the target varied from 13,000 to 4,000 feet. Three passes were made. The laser was not operational on the second run. Track was satisfactory, but the operator must continually change the position of the cursors as the helicopter approaches the target. Flight time was forty-seven minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 54°F
Wind, Surface: 5 knots from 100°T

GUIDED MISSILE LAUNCH
Flight No. 15 Test No. 269
10 March 1971

(C) This test was conducted to determine the ability of the "Big U" mount to keep the laser spot on a truck target and to determine the impact location of the missile aimed at a 12' x 12' target board. This missile was equipped with a telemetry instrumentation package. Flight altitude was 1,000 feet and ground speed was 10 knots. The missile was launched when the helicopter was at a slant range of 7,550 feet from the target. The impact point was 130 feet short and 6 feet to the left of the desired impact point. At launch the TV signal was lost and the operator was unable to observe the missile flight. The contrast tracker remained locked until the operator assumed manual control of the mount at seven seconds after launch. Missile telemetry showed that the seeker was locked on the laser spot for the complete 8.7 second flight. There was no smoke problem on this test. Post test investigation of the airborne TV transmitter revealed that it will turn off and stay off for a minimum of five seconds when the input voltage drops below 14 volts or raises above 37 volts. Flight time was twenty-nine minutes.

Weather Conditions

Barometric Pressure: 26.70" Hg
Temperature: 60°F
Wind, Surface: 12 knots from 270°T

UNGUIDED MISSILE LAUNCH
Flight No. 16 Test No. 270
15 March 1971

(C) This test was scheduled to evaluate the effect of a 1.5 degree offset between the missile and TV axis on the smoke obscuration problem. A 12' x 12' target board was used for aiming practice and for the contrast tracker. The test was cancelled when the helicopter dropped 300 feet while making a downwind turn. Flight time was thirty-six minutes.

Weather Conditions

Barometric Pressure: 26.90" Hg
Temperature: 62°F
Wind, Surface: 9 knots from 270°T
1000' 8 knots from 290°T

UNGUIDED MISSILE LAUNCH
Flight No. 17 Test No. 270
16 March 1971

(C) This test was conducted to determine if a 1.5° offset between the missile line of sight and TV camera line of sight will eliminate the smoke problem. A 12' x 12' target board was used for practice aiming and for the contrast tracker. Flight altitude was 1,000 feet and ground speed was 20 knots. When the unguided missile was launched the helicopter yawed 6 degrees to the right at a 12 degrees/second rate. This motion caused the contrast tracker to shift lock from the left to the right side of the target. Lock was then maintained until smoke from the burning rocket propellant obscured the target. Because of calibration problems the angular offset between the missile and TV axis was only 0.5 degree. During the approach to the target the pointing accuracy of the mount was adequate to maintain the laser spot within a six foot circle on the target board. Two previous attempts were made to launch this missile. Total flight time was twenty-two minutes.

Weather Conditions

Barometric Pressure: 26.88" Hg
Temperature: 50°F
Wind, Surface: Clam
1000" 4 knots from 076°T

EVALUATE HELICOPTER YAW
Flight No. - Test No. 271
17 March 1971

(C) This test was conducted to determine the cause of the helicopter yaw when the missile is launched. A 2.75" rocket motor was built up to simulate the LARS missile and fired while the helicopter was located on a turntable. At 0.03 seconds after the firing command was initiated, the helicopter started a left movement at a 0.88 degree/second rate. At 0.5 seconds, a movement to the right started at a rate of .885 degrees/second and sustained for 0.05 seconds. At 0.10 seconds the rate increased to 5.31 degrees/second and was sustained for 0.06 seconds. The helicopter yaw is caused by the buildup and friction of missile exhaust gases in the launch tube and the effect of the exhaust gases hitting the air frame as the missile exits the launch tube.

GUIDED MISSILE LAUNCH
Flight No. 18 Test No. 272
19 March 1971

(C) This test was conducted to evaluate the performance of the shaped charge warhead and to evaluate the operation of the contrast tracker. The target was an armored tank illuminated by the laser located on the ground, 500 feet in front of the tank. Flight altitude was 1,000 feet and ground speed was 25 knots. The missile was launched when the helicopter was at a slant range of 6,000 feet from the target. Signal strength at launch was 15 db above threshold. Impact was 4 feet right and 1 1/2 feet above the center of the aimpoint. The warhead did not explode. The one degree offset eliminated the smoke problem. The helicopter showed a five degree yaw to the right at a 6 degrees/second rate. The mount moved 3 mils left in 0.015 second and then moved right 3 mils in 0.025 second. At fire command plus 0.08 second, the mount was at the original lock point. The contrast tracker maintained lock during the maneuvers, but the lock point did change. One previous attempt was made to launch this missile. Total flight time was fifty-eight minutes.

Weather Conditions

Barometric Pressure: 26.98" Hg
Temperature: 51°F
Wind, Surface: 7 knots from 0°T

EVALUATE DEFLECTION PLATES
Flight No. - Test No. -
24 March - 7 May 1971

(C) During this time period tests were conducted to evaluate various exhaust deflector configurations and determine which one would reduce the yaw to an acceptable value. Eight dummy missiles were launched while the helicopter was located on a turntable. Two airborne launches were completed to evaluate the deflector configurations in flight. A deflector was developed that reduced helicopter yaw to 0.5 mil. This is an acceptable value. Contrast tracker performance was also evaluated during these tests. Mount vibration appeared to be the primary factor limiting tracker performance.

UNGUIDED MISSILE LAUNCH
Flight No. 19 Test No. 274
11 May 1971

(C) This test was conducted to evaluate contrast tracker performance and airborne laser pointing during the launch of an unguided missile. The aim-point was the center of a 20' x 20' target board. Flight altitude was 500 feet and ground speed was 20 knots. The missile was launched when the helicopter was at a slant range of 6,200 feet from the target. The contrast tracker did not lose lock at launch, but did shift lock points during the missile flight. Laser pointing was not acceptable because of vibration in the pan axis of the mount. One previous attempt was made to launch this missile. Total flight time was forty minutes.

Weather Conditions

Barometric Pressure: 26.62" Hg
Temperature: 80°F
Wind, Surface: 6 knots from 090°T

UNGUIDED MISSILE LAUNCH
Flight No. 20 Test No. 352
12 October 1971

(C) This test was conducted to test the warhead of the LARS missile and to evaluate the mount pointing ability and contrast tracker performance during launch. The aimpoint was the center of a 20' x 20' target board. Flight altitude was 500 feet and the unguided missile was launched when the helicopter was at a slant range of 5,700 feet from the target. The warhead did explode. The tracker maintained lock throughout launch and flight of the missile. No smoke or flame were observed on the TV monitor. Laser pointing data were recorded prior to this launch and show the maximum excursion in the pan axis to be 1.0 mil. The tilt axis maximum excursion was 0.3 mil. These data were collected at a slant range that varied from 6,200 to 5,700 feet. Flight time, including one run to check out all systems, was thirty-six minutes.

GUIDED MISSILE LAUNCH
Flight No. 21 Test No. 354
14 October 1971

(C) This test was conducted to launch a LARS missile equipped with a telemetry instrumentation package. The target was a 20' x 20' board and it was illuminated by the airborne laser. Flight altitude was 500 feet and airspeed was 30 knots. The guidance system was locked on the reflected signal at a range of approximately 7,800 feet and the missile was launched when the helicopter was at a slant range of 4,600 feet from the target. Flight time at this range did not allow sufficient time for the guidance system to recover from the launch transients, and impact occurred 10 feet high and 10 feet right from the center of the target. One previous attempt was made to launch this missile. Total flight time was forty-nine minutes.

<u>Weather Conditions</u>

Barometric Pressure: 26.82" Hg
Temperature: 75°F
Wind, Surface: Not available

GUIDED MISSILE LAUNCH
Flight No. 22 Test No. 355
29 October 1971

(C) This test was conducted to evaluate the performance of the tracking mount equipped with the GCA mount control electronics and gyros from another helicopter. A guided missile was launched at a stationary truck target which

was illuminated by the airborne laser. Flight altitude was 600 feet and the commanded airspeed was 28 knots. The missile was launched when the helicopter was 6,000 feet from the target. Impact occurred 1,650 feet short and 500 feet left of the target. The contrast tracker maintained lock during the launch phase, but smoke caused the contrast tracker to lose lock 0.2 second after launch. Lock was regained on several objects in the target area and was finally positioned on the proper target by the operator approximately three seconds after launch. The missile offset was apparently greater than planned. This allowed the seeker head to lock up on reflections detected by a side lobe. This problem can be corrected by a design change to the guidance logic circuit. One previous attempt was made to launch this missile. Total flight time was fifty-nine minutes.

Weather Conditions

Barometric Pressure: 26.73" Hg
Temperature: 43°F
Wind. Surface: 10 - 15 knots from 330°T
500' 12 knots from 310°T

UNGUIDED MISSILE LAUNCH
Flight No. 23 Test No. 352A
2 November 1971

(C) This test was conducted to evaluate mount and tracker performance when an unguided missile is launched. The airborne laser was used to illuminate a tank target. Flight altitude was 500 feet. The missile was launched when the helicopter was at a slant range of 5,500 feet from the target. The contrast tracker remained locked on the tank target throughout the launch. Pointing accuracy was estimated to be 1.3 mils. Three passes were made to evaluate all systems prior to launch. Flight time was seventy-seven minutes.

Weather Conditions

Barometric Pressure: 27.00" Hg
Temperature: 62°F
Wind, Surface: 8 knots from 360°T

EVALUATE MOUNT PERFORMANCE
Flight No. 24 Test No. 353A
3 November 1971

(C) This test was conducted to continue the evaluation of mount performance and to search the target area for spurious laser reflections. Flight altitude

was 600 feet and commanded airspeed varied from 30 to 50 knots. The airborne laser was used to illuminate various targets and response of the seeker head was monitored. Three runs were conducted at slant ranges varying from 9,500 to 4,800 feet. Mount performance was excellent. Oscillations were reduced to 0.6 mil in pan and 0.2 mil in tilt. The seeker head in the captive missile tracked some spurious reflections. Flight time was thirty-two minutes.

Weather Conditions

Barometric pressure: 27.08" Hg
Temperature: 58° F
Wind, Surface: 2 knots from 002° T

UNGUIDED MISSILE LAUNCH
Flight No. 25 Test No. 352B
3 November 1971

(C) This test was conducted to verify laser pointing and contrast tracker performance by launching an unguided missile. A stationary tank target was used to determine laser pointing accuracy and as a target for the contrast tracker. Flight altitude was 500 feet. The missile was launched at 6,000 feet. Tracker performance was excellent and the laser spot was observed to remain on the tank turret. Flight time was twenty-two minutes.

Weather Conditions

Barometric pressure: 27.08" Hg
Temperature: 68° F
Wind, Surface: 5 knots from 350° T

GUIDED MISSILE LAUNCH
Flight No. 26 Test No. 356
4 November 1971

(C) This test was conducted to determine the ability of the LARS missile to hit a stationary tank target. The missile carried a telemetry instrumentation package. The tank was illuminated by the airborne laser. Approach to the target was started at a slant range of 12,700 feet. Flight altitude was 500 feet and commanded airspeed was 30 knots. The missile was launched when the helicopter was at a slant range of 6,200 feet. The contrast tracker held lock at launch and throughout the missile flight. The missile hit the laser spot on the tank. The pointing capability of the mount maintained the laser spot at the base of the turret of the tank. Good telemetry data were obtained. Flight time was thirty-two minutes.

GUIDED MISSILE LAUNCH
Flight No. 27 Test No. 357
4 November 1971

(C) This test was conducted to determine the ability of the LARS to hit a tank moving approximately ?0 miles per hour. The missile carried a shaped charge warhead. The tank was illuminated by the airborne laser. Flight altitude was 500 feet. Approach to the target was started at a slant range of 10,000 feet. The seeker was locked on the reflected signal at a range of approximately 6,200 feet and the missile was launched when the helicopter was at a slant range of 5 500 feet from the target. The missile hit the laser spot, but the warhead did not explode. Ground instrumentation was not able to determine the exact position of the laser spot. Impact was estimated to be 4 feet left of the desired impact point. Flight time was nineteen minutes.

SECTION C-3
LARS II (NIGHT) TEST REPORTS

EVALUATION FLIGHT
Flight No. 1 Test No. -
7 September 1971

(U) This test was conducted to verify the operational readiness of aircraft number 1726. All systems were operated and performance was satisfactory. The aircraft was declared ready to support Test No. 322. Flight time was eighteen minutes.

Weather Conditions

Barometric Pressure: 26.70" Hg
Temperature: 82° F
Wind, Surface: 7 knots from 000° T

UNGUIDED MISSILE LAUNCH
Flight No. 2 Test No. 322
11 September 1971

(C) This test was conducted at night to evaluate the effect of the rocket flame on the contrast tracker and the LLLTV system. The missile was unguided. Flight altitude was 300 feet and ground speed was 40 knots. The direct and reflected flame/spark interference period was noted to be 1.1 seconds. LLLTV problems were prevalent throughout the flight. The contrast tracker was unable to maintain lock because of this problem. Mount vibration was a contributing cause of these problems. Flight time was forty-two minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 80° F
Wind, Surface: 5 knots from 130° T

EVALUATION FLIGHT
Flight No. 3 Test No. -
4 October 1971

(C) This test was conducted to verify the operational readiness of aircraft 1726 after a new laser and McMaster servo motors were installed on the "Big U" mount. Flight altitude was 1,000 feet and airspeed was minimum safe. The aircraft performance was satisfactory. The mount showed no evidence

of previous pan vibrations. The tracker was unable to maintain lock because of a TV problem. The problem was eliminated after the flight by adjusting the target pulse threshold. The second pass was cancelled in flight when all tilt control was lost. A third flight was made after the mount was re-balanced. Pointing accuracy was estimated to be .75 mil. Flight time was twenty-four minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 70°F
Wind, Surface: 6 knots from 350°T

EVALUATION FLIGHT
Flight No. 4 Test No. -
5 October 1971

(C) This test was conducted to evaluate system performance after servo gains had been adjusted and the mount was balanced. Flight altitude was 500 feet and airspeed was minimum safe. The downrange laser TV failed in flight and the mount TV became erratic during the data run. The pan oscillations (.75 mil) noted on a previous flight were not observed during this test. Flight time was thirty-five minutes.

Weather Conditions

Barometric Pressure: 26.92" Hg
Temperature: 77°F
Wind, Surface: 6 knots from 300°T

EVALUATION FLIGHT
Flight No. 5 Test No. -
6 October 1971

(C) This test was conducted to evaluate all systems. Airborne laser pointing accuracy was estimated to be 0.3 mil. All systems were declared ready to support the launch of an unguided missile. Flight altitude was 1,000 feet and airspeed was varied from 30 to 45 knots. Flight time was twenty-seven minutes.

Weather Conditions

Barometric Pressure: 26.80" Hg
Temperature: 82°F
Wind, Surface: 4 knots from 150°T

UNGUIDED MISSILE LAUNCH
Flight No. 6 Test No. 351A
7 October 1971

(U) This test was scheduled to exercise and evaluate all systems by launching an unguided missile. The test was cancelled in flight when tilt control was lost. Flight altitude was 500 feet. Flight time was twenty-one minutes. After the flight a circuit change was made to inhibit the operation for 1.0 second after missile launch.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: Not available
Wind, Surface: Not available

MOUNT EVALUATION
Flight No. 7 Test No. -
14 October 1971

(C) This test was conducted to evaluate the performance of the ILS laser and of the tracking mount. The downrange TV was inoperative but visual observations indicated tracking to be satisfactory. Laser ranging was satisfactory. Two passes at the target were completed. Flight time was twenty-nine minutes.

Weather Conditions

Barometric Pressure: 26.82" Hg
Temperature: 65°F
Wind, Surface: Not available

MOUNT EVALUATION
Flight No. 8 Test No. -
20 October 1971

(C) This test was conducted to evaluate the laser pointing accuracy. Four passes were made at a 20' x 20' target board. Pointing accuracy was estimated to be 1.3 mils. Flight altitude was 500 feet. Flight time was forty-six minutes.

Weather Conditions

Barometric Pressure: 26.86" Hg
Temperature: 55°F
Wind, Surface: Calm
1000' 2 knots from 080°T

MOUNT EVALUATION
Flight No. 9 Test No. -
20 October 1971

(C) This test was conducted to continue the laser pointing evaluation. The mount motor and rate loop gains were adjusted. Five passes against a 20' x 20' target board resulted in a pointing accuracy of 1.3 mils. The mount motor will be replaced because this accuracy will not keep the laser pointed at the truck target at the required launch distance. Flight altitude was 500 feet. Flight time was fifty-five minutes.

Weather Conditions

Barometric Pressure: 26.86" Hg
Temperature: 58°F
Wind, Surface: Calm
1000' 6 knots from 080°T

MOUNT EVALUATION
Flight No. 10 Test No. -
21 October 1971

(C) This test was conducted to evaluate the pointing accuracy of the airborne laser after a softer pan axis sector gear was installed. Two data runs were made against a target board for a check on pointing accuracy and a third run was made against a truck. The pan axis movement was 0.8 mil. Flight altitude was 500 feet. Airspeed was varied from 30 to 45 knots. Flight time was twenty-six minutes.

Weather Conditions

Barometric Pressure: 26.86" Hg
Temperature: 58°F
Wind, Surface: Not available

LLLTV EVALUATION
Flight No. 11 Test No. -
28 October 1971

(C) This test was conducted to evaluate the performance of the LLLTV. Lift-off occurred at 0430 local time. LLLTV performance was poor, however microphonics observed in ground tests did not appear during the flight. Pan oscillations appear to have been eliminated but a 2.0 mil oscillation developed in the tilt axis. Flight altitude was 500 feet. Airspeed was varied from 30 to 50 knots. Flight time was forty minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 30°F
Wind, Surface: 20 - 30 knots from 200°T

LLLTV EVALUATION
Flight No. 12 Test No. -
28 October 1971

(C) This test was conducted to continue the LLLTV evaluation. Lift-off was at 2400. Mount performance was better than the previous flight. The targets were visible on the TV monitor. The helicopter hovered over the pad at an altitude of 150 feet. Flight time was twenty-three minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 50°F
Wind, Surface: Not available

EVALUATION FLIGHT
Flight No. 13 Test No. -
9 November 1971

(C) This test was conducted to evaluate all systems. The mount was unstable because of severe oscillations in the tilt axis. TV video was lost and the flight was terminated. Flight altitude was 200 feet and airspeed was 35 knots. Flight time was nine minutes.

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Weather Conditions

Barometric Pressure: 26.88" Hg
Temperature: 60°F
Wind, Surface: 10 - 1r knots from 120°T

MOUNT EVALUATION
Flight No. 14 Test No. -
10 November 1971

(C) This test was conducted during the day to evaluate tracking mount performance after the mount gains had been adjusted. Two runs were made and the mount oscillations were determined to be too large for a successful launch. Flight altitude was 200 feet and airspeed was 30 knots. Flight time was eighteen minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 69°F
Wind, Surface: 10 knots from 100°T

MOUNT EVALUATION
Flight No. 15 Test No. -
10 November 1971

(C) This test was conducted at night to evaluate the tracking mount after adjustments were made. Excessive jitter was still present in the tilt axis. Improvement was noted in the pan axis. Target observation indicated that the LLLTV should be refocused. Flight altitude was 500 feet and airspeed was 30 knots. Flight time was twelve minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 65°F
Wind, Surface: 10 - 12 knots from 160°T

CONFIDENTIAL

MOUNT EVALUATION
Flight No. 16 Test No. -
11 November 1971

(C) This test was conducted at night to evaluate mount performance after the LLLTV camera installation was made more rigid. Visual observations indicated that mount vibrations had been reduced. Flight altitude was 500 feet and airspeed was varied from 30 to 55 knots. Flight time was thirty-nine minutes.

Weather Conditions

Barometric Pressure: 26.72" Hg
Temperature: 64°F
Wind, Surface: 7 - 15 knots from 120° T

UNGUIDED MISSILE LAUNCH
Flight No. 17 Test No. 323
12 November 1971

(C) This test was scheduled to exercise and evaluate all systems by launching an unguided missile. A target board was used for aiming practice and for the contrast tracker. Lift-off was scheduled for 2000 hours. Several problems developed and were eliminated during the ground check out. The contrast tracker maintained lock during the firing approach. Lock was lost after launch when sparks from the rocket motor blanked out the LLLTV. The gain control did not recover in time and automatic track was not regained. The time that the inhibit circuit is active will be extended beyond the present one second to inhibit TV track during the rocket flame period. Flight altitude was 500 feet and airspeed at launch was 30 knots. Flight time was fifty minutes.

Weather Conditions

Barometric Pressure: 26.70" Hg
Temperature: 48°F
Wind, Surface: 7 - 12 knots from 240° T

MOUNT EVALUATION
Flight No. 18 Test No. -
15 November 1971

(C) This test was conducted to determine the performance of the tracking mount after the KORAD laser was removed and the ILS laser installed. The mount was re-balanced and the systems were boresighted after the ILS laser

was installed. In flight, excessive motion was noticed in the pan axis. Flight time was twenty-five minutes.

Weather Conditions

Barometric Pressure: Not available
Temperature: 40°F
Wind, Surface: 8 - 12 knots from 330° T

UNGUIDED MISSILE LAUNCH
Flight No. 19 Test No. 323A
15 November 1971

(C) This test was conducted to exercise and evaluate all systems by launching an unguided missile at night. The test was cancelled in flight because of poor TV performance and the inability of the tracker to maintain lock. Flight altitude was 500 feet and airspeed was 30 knots. Flight time was thirty minutes.

Weather Conditions

Barometric Pressure: 26.76" Hg
Temperature: 40°F
Wind, Surface: 5 knots from 190° T

UNGUIDED MISSILE LAUNCH
Flight No. 20 Test No. 323A
16 November 1971

(C) This test was conducted to exercise and evaluate all systems by launching an unguided missile at night. During the first pass, the contrast tracker would not maintain lock on the tank. The missile was launched on the second pass. The tracker lost lock at launch but regained automatic track when the inhibit function was completed. Another pass was made and mount control was lost. A broken resistor lead was replaced after the flight. Flight altitude was 500 feet and airspeed at launch was 30 knots. Flight time was forty minutes.

Weather Conditions

Barometric Pressure: 26.80" Hg
Temperature: 46°F
Wind, Surface: 10 knots from 300° T

CONFIDENTIAL

MOUNT EVALUATION
Flight No. 21 Test No. -
17 November 1971

(C) This test was conducted to verify the operational readiness of the system after mount repairs were completed. All systems operated satisfactorily. Flight altitude was 500 feet and airspeed was varied from 30 to 50 knots. Flight time was twenty-six minutes.

Weather Conditions

Barometric Pressure: 26.84" Hg
Temperature: 53°F
Wind, Surface: Calm

UNGUIDED MISSILE LAUNCH
Flight No. 22 Test No. 323B
17 November 1971

(C) This test was conducted to exercise and evaluate all systems by launching an unguided missile at night. Flight altitude was 500 feet and ground speed was 30 knots. On the first pass at the target the contrast tracker would not lock on the tank target. The laser illuminator failed on the second pass. The tracker would not maintain lock during the third pass and the test was cancelled. Flight time was thirty-five minutes.

Weather Conditions

Barometric Pressure: 26.87" Hg
Temperature: 48°F
Wind, Surface: 5 knots from 310° T

EVALUATION FLIGHT
Flight No. 23 Test No. 950
21 January 1972

(C) This test was scheduled to evaluate all systems of aircraft 1725. This was the first flight of 1725 in the night LARS configuration. This was a night flight and the G.E. LLLTV was used. The test was aborted when compressor and rotor readings were not available from the telemetry system. Flight time was five minutes.

CONFIDENTIAL

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Weather Conditions

Barometric Pressure: Not available
Temperature: 35°F
Wind, Surface: Light and variable

EVALUATION FLIGHT
Flight No. 24 Test No. 951
24 January 1972

(C) This test was conducted to evaluate system performance at night. The focus of the LLLTV was adjusted before the flight. A wiring error was discovered and repaired during the ground check out. Excessive pan jitter was detected and the flight was aborted. A loose lens support was discovered after the flight. Flight altitude was 500 feet and airspeed was 50 knots. Flight time was twenty-one minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 35°F
Wind, Surface: Light and variable

MOUNT EVALUATION
Flight No. 25 Test No. 952
25 January 1972

(C) This test was conducted during daylight hours to evaluate the mount performance after the LLLTV was properly located and firmly mounted. Performance during the flight was satisfactory. Flight altitude was 300 feet and airspeed was 40 knots. Flight time was sixteen minutes.

Weather Conditions

Barometric Pressure: 26.48" Hg
Temperature: 52°F
Wind, Surface: 10 - 25 knots from 120°T

CONFIDENTIAL

LLLTV EVALUATION
Flight No. 26 Test No. 953
25 January 1972

(C) This test was conducted at night to evaluate the LLLTV system. Flight altitude was 500 feet and airspeed was varied from 30 to 50 knots. The gusting winds caused the helicopter air frame to vibrate and a camera box broke loose from a mounting bracket. Two passes against a 20' x 20' target board were completed before the trouble occurred. The TV picture deteriorated near the end of the second pass. Flight time was fifty-two minutes.

Weather Conditions

Barometric Pressure: 26.46" Hg
Temperature: 45°F
Wind, Surface: 20 - 30 knots from 130° T

EVALUATION FLIGHT
Flight No. 27 Test No. 954
26 January 1972

(C) This test was conducted at night to evaluate all systems after repairs had been made to the camera mount and antenna covers. Flight altitude was 500 feet and airspeed was 45 knots. The test was terminated when the TV power supply and the mount tilt control failed.

Weather Conditions

Barometric Pressure: 26.52" Hg
Temperature: 40°F
Wind, Surface: 10 - 15 knots from 180° T

EVALUATION FLIGHT
Flight No. 28 Test No. 955
27 January 1972

(C) This test was conducted during daylight to verify that all systems were capable of supporting a missile launch. One run was made against a 20' x 20' target board, and two more runs using the tank as a target. These runs indicated that the systems should be boresighted prior to a launch test. The contrast tracker lost lock when the inhibit cycle was activated. Mount performance was satisfactory. Flight altitude was 500 feet and airspeed varied from 25 to 50 knots. Flight time was thirty-eight minutes.

Weather Conditions

Barometric Pressure: 26.74" Hg
Temperature: 39°F
Wind, Surface: 5 - 10 knots from 120°T

UNGUIDED MISSILE LAUNCH
Flight No. 29 Test No. 425
27 January 1972

(C) This test was conducted to exercise and evaluate all systems by launching an unguided missile at night. A tank target was used as the aimpoint. Flight altitude was 500 feet and airspeed was 28 knots. The LLLTV lens was used in the wide angle position because the full zoom setting caused a contrast reduction. The laser illuminator was not used because moonlight provided adequate illumination for the contrast tracker. The tracker lost lock at launch but immediately regained track. An oscillation developed in the tracking gate that would have caused a guided missile to miss the target. Flight time was forty minutes.

Weather Conditions

Barometric Pressure: 26.74" Hg
Temperature: 34°F
Wind, Surface: Calm

UNGUIDED MISSILE LAUNCH
Flight No. 30 Test No. 426
27 January 1972

(C) This test was conducted to exercise and evaluate all systems by launching an unguided missile at night. A tank was used as a target. Flight altitude was 500 feet and airspeed was 28 knots. The LLLTV was operated at the wide angle lens setting. The contrast tracker lost lock at launch. At launch the helicopter yawed and lost approximately 60 feet altitude. The helicopter reaction indicated that the missile exit from the launch tube was not normal. The missile appeared to drop straight down after firing. Flight time was twenty-one minutes.

Weather Conditions

Barometric Pressure: 26.74" Hg
Temperature: 32°F
Wind, Surface: Calm

CONFIDENTIAL

UNGUIDED MISSILE LAUNCH
Flight No. 31 Test No. 427
28 January 1972

(C) This test was conducted at night to evaluate the LLLTV and mount performance by launching an unguided missile. The airborne laser was pointed at a stationary tank target. Flight altitude was 500 feet and airspeed was 50 knots. Contrast tracker lock was maintained throughout the flight. New stabalizers were installed on the helicopter prior to this flight. There was no drift during the LLLTV inhibit cycle. One previous attempt to launch this missile was cancelled in flight when the TV camera failed. Total flight time was forty-five minutes.

Weather Conditions

Barometric Pressure: 26.84" Hg
Temperature: 34°F
Wind, Surface: 5 knots from 180° T

GUIDED MISSILE LAUNCH
Flight No. 32 Test No. 428
31 January 1972

(C) This test was conducted to evaluate the LLLTV and tracking mount performance, and to determine the miss distance of the guided missile. This was a night flight and the airborne laser was used to illuminate the stationary tank target. The LLLTV lens was set at the wide angle position. Flight altitude was 500 feet and airspeed was 30 knots. Approach to the target was started at 15,000 feet and all systems were declared ready for launch at 7,000 feet. The missile was launched when the helicopter was 6,000 feet from the target. The contrast tracker lock broke immediately after the inhibit function was completed because rocket motor debris blanked out the TV. The missile over-flew the target and impact data were not obtained. Visual observations from the ground indicate that the rocket motor burned longer than expected. Prior to launch, mount tracking was excellent. One previous attempt to launch this missile was cancelled because of a TV problem. Total flight time was thirty minutes.

Weather Conditions

Barometric Pressure: 26.48" Hg
Temperature: 33°F
Wind, Surface: 5 knots from 190° T

CONFIDENTIAL

GUIDED MISSILE LAUNCH
Flight No. 33 Test No. 429
2 February 1972

(C) This test was conducted to determine the ability of the system to hit a stationary tank target at night. In an attempt to eliminate the missile debris problem that occurred on Test 428, the missile and tracker axis were offset approximately 2.5 degrees. Flight altitude was 500 feet and commanded airspeed was 38 knots. The contrast tracker achieved lock at 12,000 feet, the missile was armed at approximately 11,000 feet and the missile was launched when the helicopter was at a slant range of 8,100 feet from the target. At launch, the tracker appeared to lose lock because of a bright flash on the TV that occurred before the inhibit function was activated. The inhibit function operated for the normal 1.5 seconds. At the time this function was completed the track gate was positioned on the visible trail left by the missile passing through the TV field of view, and the contrast tracker started tracking this trail. The missile passed through the TV field of view and the tracking gate because it made a hard left turn immediately after leaving the launch tube. This hard over left turn was made by the guidance system to compensate for the initial 2.5 degree offset. When the operator realized the contrast tracker was following the missile path rather than the target, he assumed manual control of the mount and attempted to position the laser spot on the target. The remaining flight time was too short for the missile guidance system to make the required corrections. Missile impact occurred approximately 100 feet left of the target. Four dry runs were made and launch was accomplished on the fifth run. Total flight time was one hundred twenty-five minutes.

Weather Conditions

Barometric Pressure: 26.74" Hg
Temperature: 35° F
Wind, Surface: 3 knots from 330° T

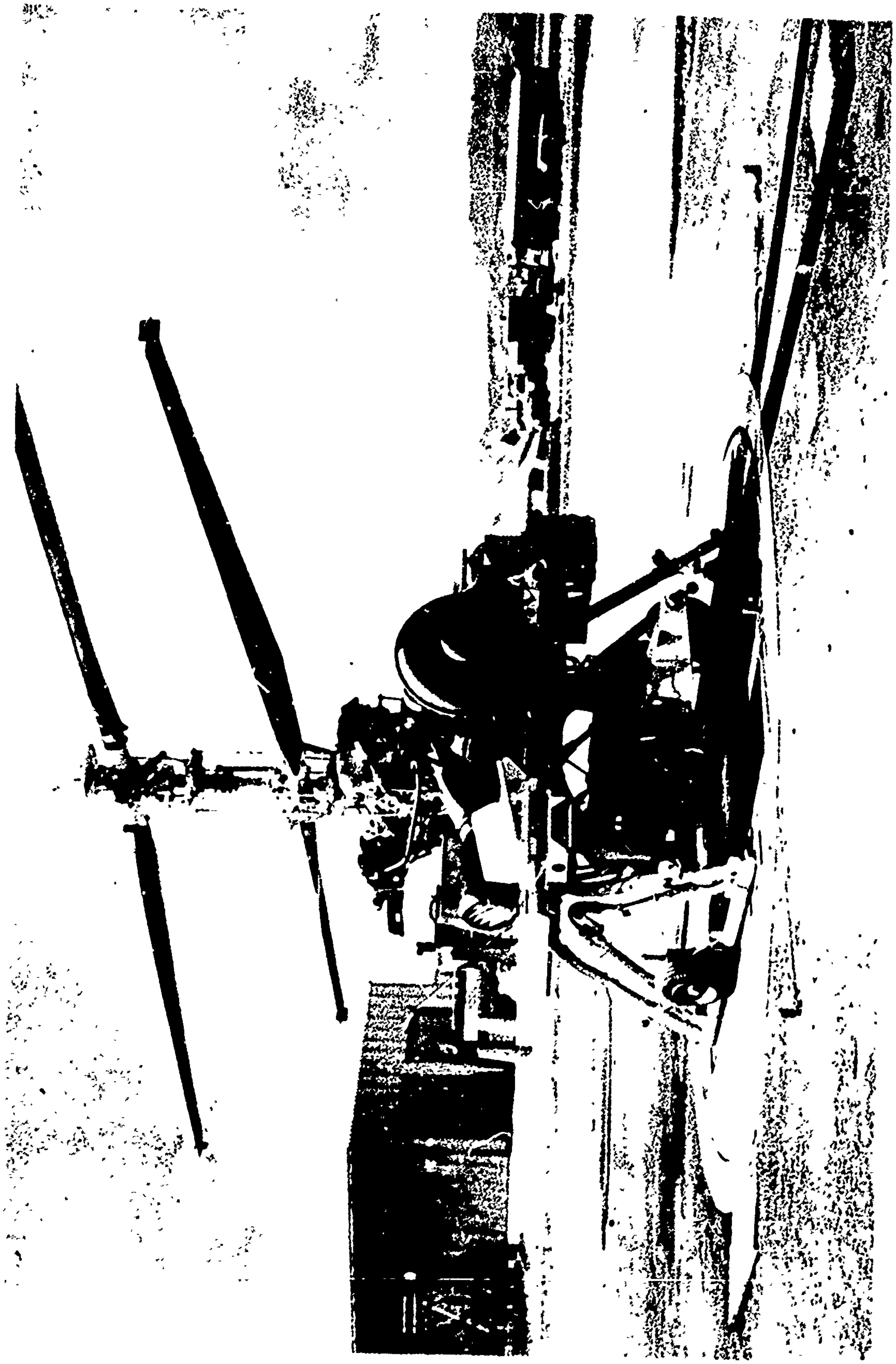
7.0 NITE GAZELLE/HYPERVELOCITY GUN WEAPON SYSTEM (U)

ABSTRACT

(C) The NITE GAZELLE/Hypervelocity Gun Weapon System was designed to attack trucks from standoff ranges up to 2,500 feet. The Hypervelocity Gun fires a 185 grain flechette which penetrates the engine block of a truck. Muzzle velocity is 4,450 feet per second.

(U) The system was tested at Range 3 of Nellis AFB, Nevada from 21 April 1970 through 24 November 1971. The test program consisted of contrast tracker accuracy evaluation tests, ground boresighting tests and flight tests against stationary bull's-eye targets.

(C) During the test program, a contrast tracker, laser range finder and a fire control computer were installed on the helicopter to improve system accuracy. Airborne firings prior to the use of these systems resulted in a dispersion of 3.5 mils. Tests conducted with the fire control computer resulted in an average impact dispersion of 1.13 mils. Eliminating the impacts of bad rounds of ammunition fired during the latter part of the test period results in a dispersion of 0.6 mil.



NITE GAZELLE/Hypervelocity
Gun on Pad

Figure 1

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the Hypervelocity Gun Weapon System on the remotely piloted NITE GAZELLE helicopter. This weapon system is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems.

(C) The ARPA/Advanced Sensors NITE GAZELLE remotely piloted helicopter, with appropriate day/night sensors and target kill weapons, was conceived as an interdiction system to counter enemy infiltration along the waterways and roads of Southeast Asia. The sensors were selected to give the helicopter a real time navigation, target acquisition and optical fire control capability both during the day and under low light level conditions of night.

(C) The weapon package of the NITE GAZELLE/Hypervelocity Gun Weapon System was designed to destroy river vessels, trucks and armored vehicles. The helicopter, a Navy-Gyrodyne QH-50D ASW-20, is remotely piloted auto-flight controlled, with the ground command and control elements of the system in a trailer van.

(C) The ARPA NITE GAZELLE/Hypervelocity Gun Weapon System can be remotely piloted to any point within a 35 nautical mile radius and provides 30 minutes on station at its tactical destination. The helicopter is navigated through the use of Distance and Azimuth Measuring Equipment (DAME). Wide angle TV video is transmitted to the control station for real time visual search for targets. The gun controller, using the TV zoom lens, can zoom in on acquired targets or points requiring closer scrutiny. The TV video with projected reticle gives the gun controller an accurate aiming device. The Hypervelocity Gun, which is a modified M3 .50 caliber machine gun, can fire up to 200 rounds of special ammunition at targets within its effective range of 2,500 feet.

(C) The flight test program covered by this report was conducted at Nellis Air Force Base, Nevada, from 21 April 1970 through 24 November 1971. Rounds of Hypervelocity Gun flechette ammunition were fired at stationary bull's-eye targets in order to evaluate system accuracy. Other tests were conducted to evaluate contrast tracker accuracy, boresighting accuracy and basic weapon accuracy. A total of twenty flight tests were conducted during the test program. Testing was terminated prior to completion of the planned test program in that no firings were attempted against a moving target and also, in that no airborne burst firings were made.

2.0 RESULTS

2.1 Summary of Test Results

(U) The ARPA NITE GAZELLE/Hypervelocity Gun test program consisted of contrast tracker accuracy evaluation tests, ground boresighting tests and flight tests firing hypervelocity rounds against stationary bull's-eye targets located on the ground. In addition, hardstand firings were conducted to determine basic weapon accuracy and for a comparative analysis of various modifications for restraining the gun barrel.

(C) The Hypervelocity Gun test program ran from 21 April 1970 through 24 November 1971. In January 1971 a fire control computer and a laser range finder were installed to improve system accuracy. Airborne firings prior to the use of these systems resulted in a dispersion of 3.5 mils. Tests conducted with the fire control computer resulted in an average impact dispersion of 1.13 mils. Eliminating the impacts of bad rounds of ammunition fired during the latter part of the test period results in a dispersion of 0.6 mil. Hypervelocity Gun test results are summarized in Table 1.

TABLE 1 (Title Unclassified
Table Confidential)

SUMMARY OF HV GUN TEST RESULTS
December 1970 thru May 1971

Date	Operation	No. of Rounds	Radial Dispersion (mils)	Centroid $\bar{x}$ (mils)	Centroid $\bar{y}$ (mils)
12/1/70	Ground Test 73A	8	1.00	-.30	+.22
12/3/70	Flight Test 75	5	3.08	+.92	-.09
12/4/70	Flight Test 76	3	3.80	+1.28	.99
1/71	Fire Control Computer and Laser Range Finder Installed				
2/22/71	Ground Test 242	5	1.18	-1.68	+1.06
2/23/71		10	.88	-.29	-.78
2/24/71		5	.96	+.72	+.21
4/12/71		7	.85	+2.06	+1.11
4/14/71		8	1.23	+.57	-.42
4/15/71		16	.74	+.15	-.11
	(Composite Error)	(51)	(.95)		
4/25/71	Flight Test 243	4	1.92	-.72	+.53
5/20/71		10	1.00	+.47	+.13
	(Composite Error)	(14)	(1.13)		

2.2 Discussion of Test Results

(C) Approximately forty-five contrast tracker runs were completed to gain operational experience and to determine tracking accuracy. The contrast

tracker/mount successfully tracked at angular rates up to 1.7 degrees per second and test results show an RMS error ±.5 mil at target speeds up to 10 mph.

(C) Fifty-nine rounds of flechette were fired in boresigl ' and calibration testing of the Hypervelocity Gun Weapon System. The boresighting accuracy attained by the end of boresight testing on 15 April 1971 was .19 mil. The mean dispersion on the boresighting calibration tests was .95 mil.

(C) Flight test accuracy for firing at a stationary target, exceeded 3 mils for tests conducted prior to installation of the fire control computer. Flight test accuracy achieved on 20 May 1971 was 1.00 mil for dispersion and a bias of .49 mil. Aiming error was measured at .31 mil, only a small component of the 1.00 mil dispersion.

(C) A total of twenty flights were conducted, fourteen of which were aborted in flight due to the following reasons.

Helicopter:	Yaw axis malfunction (once); fuel indicator problem (once).
Mount:	No tilt control (once).
Gun:	Gun jammed (twice).
Day TV:	Poor reception (once); synchronization problem (once).
Laser Ranger:	No range readouts (twice); intermittent readout (once).
CT/FCC:	No contrast tracker lock (once); cursor movement in tilt axis (three times).

(C) Hardstand firings were undertaken in April 1971 to verify reputed gun accuracy and to simplify the evaluation of several modifications to be tested. A barrel clamp, a barrel brace and a new barrel bushing were tested. Results showed best accuracy with no clamp, no brace and the new barrel bushing. It was noted during this testing that 20% of the rounds fired went wild. Six of thirty-four rounds tumbled.

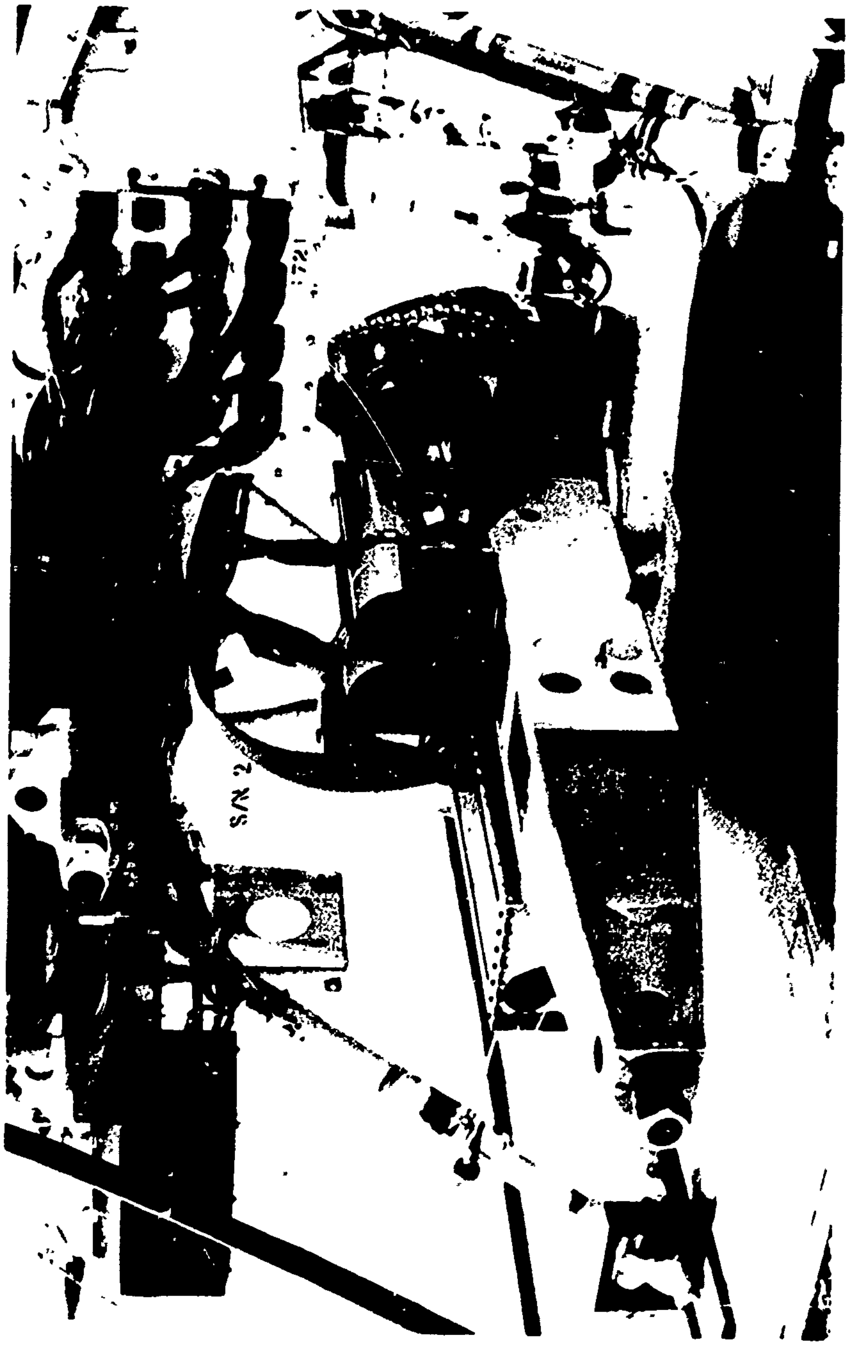
(C) Hardstand firings were again undertaken in November 1971 to check new ammunition and again to verify the reputed gun accuracy. Firings were conducted both with and without a shroud. Thirteen of fifteen sets of firings exceeded .5 mil accuracy after deleting the wild rounds. The mean dispersion was .70 mil. Twenty-seven of 159 rounds (17%) were either wild or they tumbled. Eighteen of 79 rounds (23%) were bad with the shroud attached while only 9 of 80 rounds (11%) were bad with the shroud removed. A plastic build-up was noted in the barrel after about 50 rounds. Better results were obtained after cleaning the barrel.

(C) Testing of the NITE GAZELLE/Hypervelocity Gun Weapon System was terminated prior to completion of the planned test program. No airborne firings were attempted against a moving target. Also, no airborne burst firings were made.

3.0 SYSTEM DESCRIPTION

(C) The Hypervelocity Gun is a modified M3 .50 caliber machine gun. For the test program, a system to remotely charge new and eject spent cartridges was developed. To inhibit burst firings, dummy rounds were alternately placed in the ammunition belt. The Hypervelocity Gun is mounted on the "Big U" mount of the NITE GAZELLE remotely piloted helicopter.

(C) The Hypervelocity Gun Weapon System uses a television camera for target acquisition. a contrast tracker for precision target tracking, a fire control computer for expected impact point calculations and a laser range finder for range-to-target readouts.



HV Gun and Sensors on
"Big U" Mount
Figure 2

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The primary objectives of the Hypervelocity Gun test program were:

1) To provide an assessment of the effectiveness of the Hypervelocity Gun when operated on the NITE GAZELLE with a manual fire control system and a contrast tracker with manual offset.

2) To provide an assessment of the effectiveness of the Hypervelocity Gun when operated on the NITE GAZELLE with a fire control computer system.

(C) Secondary objectives of this test program were:

1) To provide an assessment of the Hypervelocity Gun performance under flight conditions.

2) To provide an assessment of the effect of the Hypervelocity Gun's operation on the helicopter's performance.

3) To demonstrate the capability of the contrast tracker in manual offset mode.

4) To evaluate the contrast tracker performance when used with the operating Hypervelocity Gun.

4.2 Test Plan

(C) Contrast tracker tracking accuracy tests were performed with the helicopter at rest on the pad. The mount operator tracked a truck at 1, 500 feet in range in both the manual and contrast tracker modes, as the truck made runs at 0, 5, 10 and 20 mph. Tracking errors were measured either on the mount film or the video tape playback.

(C) Boresighting and calibration tests were conducted with the helicopter on the launch pad with auxiliary power on and engine power off. A sight alignment instrument was installed in the gun barrel to align the gun axis to the center of a bull's-eye target 1, 500 feet away. Using the contrast tracker to lock on to the target and the TV reticle for aiming, seven rounds were fired. The centroid of the round impacts was computed and marked on the target. The TV reticle, contrast tracker electronic cursors, laser and gun camera were all collimated using the gravity drop offset and the physical mount displacements from the gun with respect to the centroid. Another set of seven rounds was fired to confirm alignment.

(C) Flight tests were conducted firing at a stationary bull's-eye target

from ranges of 1,500 and 2,000 feet, altitudes under 1,000 feet and ground speed of less than 10 knots. The aimpoint for each round fired was recorded on mount camera film and TV video. Round impacts were measured on the target, and a centroid and dispersion were computed.

5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the following areas:

Hypervelocity Gun
Helicopter
Data Link
Ground Station
Television
Contrast Tracker/Fire Control Computer
Laser Range Finder
Tracking Mount

5.1 Hypervelocity Gun

5.1.1 Conclusions

5.1.1.1 Defective Ammunition

(C) Defective ammunition is degrading system accuracy and potential weapon effectiveness.

5.1.1.2 Plastic Buildup in Barrel

(C) Results of limited testing show that plastic buildup in the barrel from the sabots may be degrading system accuracy.

5.1.1.3 Unrestrained Barrel

(C) Results of limited testing indicate that the best accuracy for single round firings of the Hypervelocity Gun is attained with an unrestrained barrel.

5.1.2 Recommendations

5.1.2.1 Defective Ammunition

(U) None

5.1.2.2 Plastic Buildup in Barrel

(C) The gun barrel should be frequently cleaned to remove the plastic buildup.

5.1.2.3 Unrestrained Barrel

(C) More testing is desirable, both to confirm the superior accuracy of an unrestrained barrel for rounds fired singly and to determine the accuracies

for burst firings using both an unrestrained barrel and a restrained barrel.

5.2 Helicopter

5.2.1 Conclusions

(C) The helicopter proved to be a reliable vehicle during the test program.

5.2.2 Recommendations

(U) None

5.3 Data Link

5.3.1 Conclusions

(C) The data link performance for command data to the helicopter and response data from the helicopter was satisfactory.

5.3.2 Recommendations

(U) None

5.4 Ground Station

5.4.1 Conclusions

(C) The ground station proved to be effective for all aspects of the test program.

5.4.2 Recommendations

(U) None

5.5 Television

5.5.1 Conclusions

(C) The high resolution television system provided satisfactory information for target location and identification.

5.5.2 Recommendations

(U) None

5.6 Contrast Tracker/Fire Control Computer

5.6.1 Conclusions

(C) Airborne system accuracy with the contrast tracker/fire control computer is as good as ground boresight calibration firings and aiming accuracy permit.

5.6.2 Recommendations

(U) None

5.7 Laser Range Finder

5.7.1 Conclusions

(C) Whenever the tracking mount is adjusted to lead a moving target, or whenever it is adjusted to correct for gravity drop, an undesirable consequence is that the laser aiming is adjusted an equal amount, since the laser range finder is rigidly fixed to the tracking mount. This adjustment will often be large enough to move the laser spot off the target. Erroneous range information results and the contrast tracker/fire control computer system becomes inoperative.

5.7.2 Recommendations

(C) A means of independently aiming the laser ranger and Hypervelocity Gun would result in a more flexible system. If the ranger was kept on the target during lead and gravity corrections by the weapon aiming system, larger target speeds and gravity corrections could be tolerated without excessive range errors. As an alternative, software changes could improve the existing system.

5.8 Tracking Mount

5.8.1 Conclusions

(C) Testing with the "Big U" torquer driven tracking mount was insufficient to make an evaluation.

5.8.2 Recommendations

(U) More testing is needed.

BIBLIOGRAPHY

1 "Big Eagle Hardware Summary (U)", Confidential Report, ARPA, 1970.

2 "Test Report of Hypervelocity Gun Mounted on NITE GAZELLE (U)", Confidential Report, ARPA, October 1970.

3 "NITE GAZELLE Fire Control Computer/Tracker Final Report (U)", Confidential Report, ARPA, May 1971.

GLOSSARY

CT/FCC	Contrast Tracker/Fire Control Computer
DAME	Distance and Azimuth Measuring Equipment
HV	Hypervelocity
PTP	Peak to Peak
RMS	Root Mean Square

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(C) The system under test consists of a modified M3 .50 caliber machine gun which fires a 185 grain flechette with a muzzle velocity of 4,450 feet per second. The gun is fired from a remotely piloted helicopter.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE remotely piloted helicopter is a modified counter-rotating, double-bladed helicopter, which was originally developed by the U. S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding an 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius of the NITE GAZELLE/Hypervelocity Gun Weapon System is 35 nautical miles with 30 minutes on station.

2.2 The Surveillance Tracking and Weapons Mount

(C) The "Big U" is a rate commanded, inverted U-shaped, gyro-stabilized weapon/sensors mount. The sensors are mounted on a platform suspended between the two arms of the "Big U". The mount insulates the sensors from extraneous vibrations.

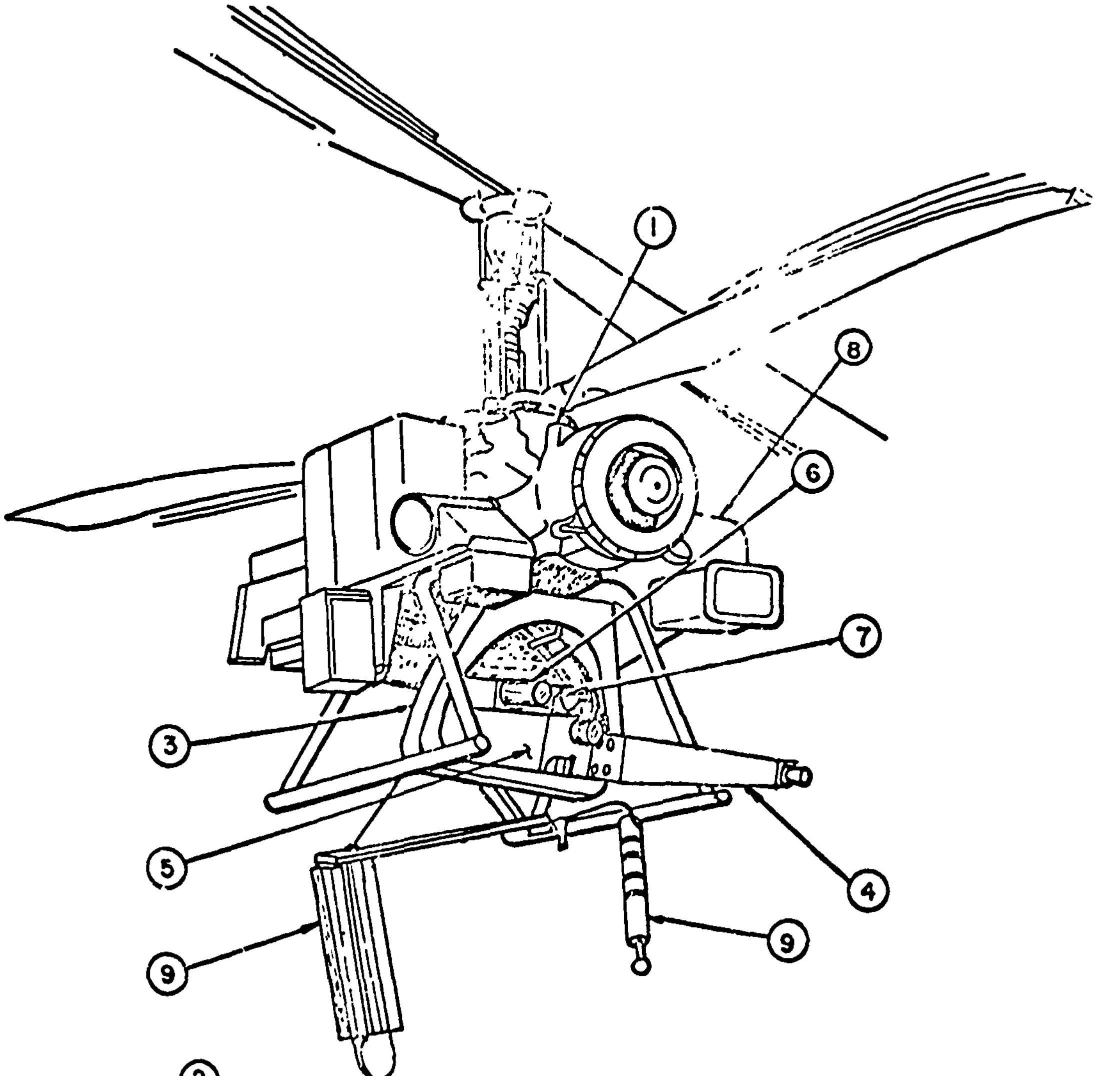
(C) The platform is remotely controlled in pan and tilt for accurate target tracking. The "Big U" can be moved through a traverse angle of $\pm 25°$ at a maximum pan rate of 2° per second. The platform can be depressed from the horizontal to -100° at a maximum tilt rate of 3° per second. Mechanical constraints limit platform depression to -60° when the Hypervelocity Gun is installed.

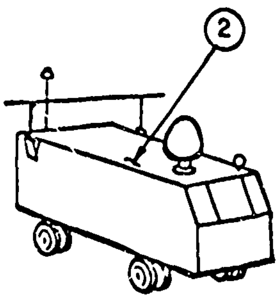
(U) The mount is centrally located under the drive shaft to provide maximum stability during in flight operations.

2.3 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and a fire control position for target acquisition and optical fire control capability.

(U) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF





NITE GAZELLE HYPERVELOCITY GUN

1. HELICOPTER DRONE QH-50D (UNFAIRED)
2. NITE GAZELLE CONTROL VAN
3. SURVEILLANCE TRACKING AND WEAPON MOUNT, "BIG U"
4. HYPERVELOCITY GUN
5. LASER RANGER
6. 16MM MOTION PICTURE CAMERA
7. DAY TELEVISION
8. CONTRAST TRACKER/FIRE CONTROL COMPUTER
9 ANTENNA

Figure A1

link. Telemetered helicopter response data are sent to the ground via an S-band link, and TV imagery is transmitted to the ground via an L-band link.

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communication relay system, permits operations beyond ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

(U) The fire controller monitors the surveillance tracking and controls the mount while viewing TV video. He controls the TV camera zoom lens, the 16 mm film camera, and transmits the firing signals.

2.4 The Hypervelocity Gun

2.4.1 General

(C) The Hypervelocity Gun is mounted on the "Big U", a platform located underneath the helicopter which is remotely controlled in pan and tilt to point the weapon and sensors at the target. A day television camera is mounted just above the gun and provides the visual means for remote optical fire control. Navigation is accomplished by observing the position of the helicopter on the plotting board. The day television system is used to recognize landmarks and to seek out potential targets. When a target is selected, the pilot starts his firing approach from a slant range of about twelve thousand feet from the target. The laser range finder is turned on and laser reflections should be observed by ten thousand feet. The ground controller tracks the target either manually or by means of the contrast tracker. The fire control computer computes a predicted projectile impact point and an electronic cursor denotes this point on the TV screen. The ground controller repositions the mount to place these electronic cursors over the desired impact point on the target. The gun is fired through the use of a command control system by the ground controller when the predicted impact point is on target at target ranges of 2500 feet or less.

2.4.2 Weapon Specifications

(C) The Hypervelocity Gun is a modified M3 .50 caliber machine gun. It has a smooth bore, is 73 inches long, 10.3 inches wide, 6 inches high and weighs 118.5 pounds. For the test program, a system to remotely charge new and eject spent cartridges was developed. To inhibit burst firings, dummy rounds were alternately placed in the ammunition belt.

(C) The gun fires a 185 grain flechette with a muzzle velocity of 4,450 feet per second. At the 2,500 foot maximum effective range of this weapon

system, the projectile velocity has decreased to 3,000 feet per second.

(C) The flechette is machined from depleted uranium rods. Fins, canted at a slight angle to provide spin stability in flight are crimped on the rod. The rod is encased in a three segment plastic sabot. The sabot transmits energy to the flechette while in the bore of the gun. Within a very short distance from the muzzle, the sabot is separated from the flechette.

(C) In the airborne configuration, two hundred cartridges and links weigh 46.8 pounds. A total of 200 rounds can be carried.

(C) Penetration in mild steel at an angle of 60° is 1.5 inches.

2.5 Day Television System

(U) The day television system is used as the primary daytime sensor on the NITE GAZELLE/Hypervelocity Gun Weapon System. The camera system is manufactured by COHU Electronics Corporation. The cylindrical camera unit is 4 inches in diameter, 19 inches long and weighs 11 pounds. Resolution is 945 lines at one footcandle illumination on the face plate. The camera control unit weighs 15 pounds.

(U) The camera lens is a 15 mm to 150 mm zoom with a 2X extender changing focal length and zoom to 30 mm to 300 mm, f5.6 to f22, covering a field of view of 23 degrees down to 2.3 degrees at full zoom. The zoom and f-stop and focus are remotely controlled from the fire controller's station on the ground. A projected reticle with a remotely controlled intensity is also provided.

(U) The TV transmission bandwidth is 14.8 MHz, with a power requirement of 45 watts.

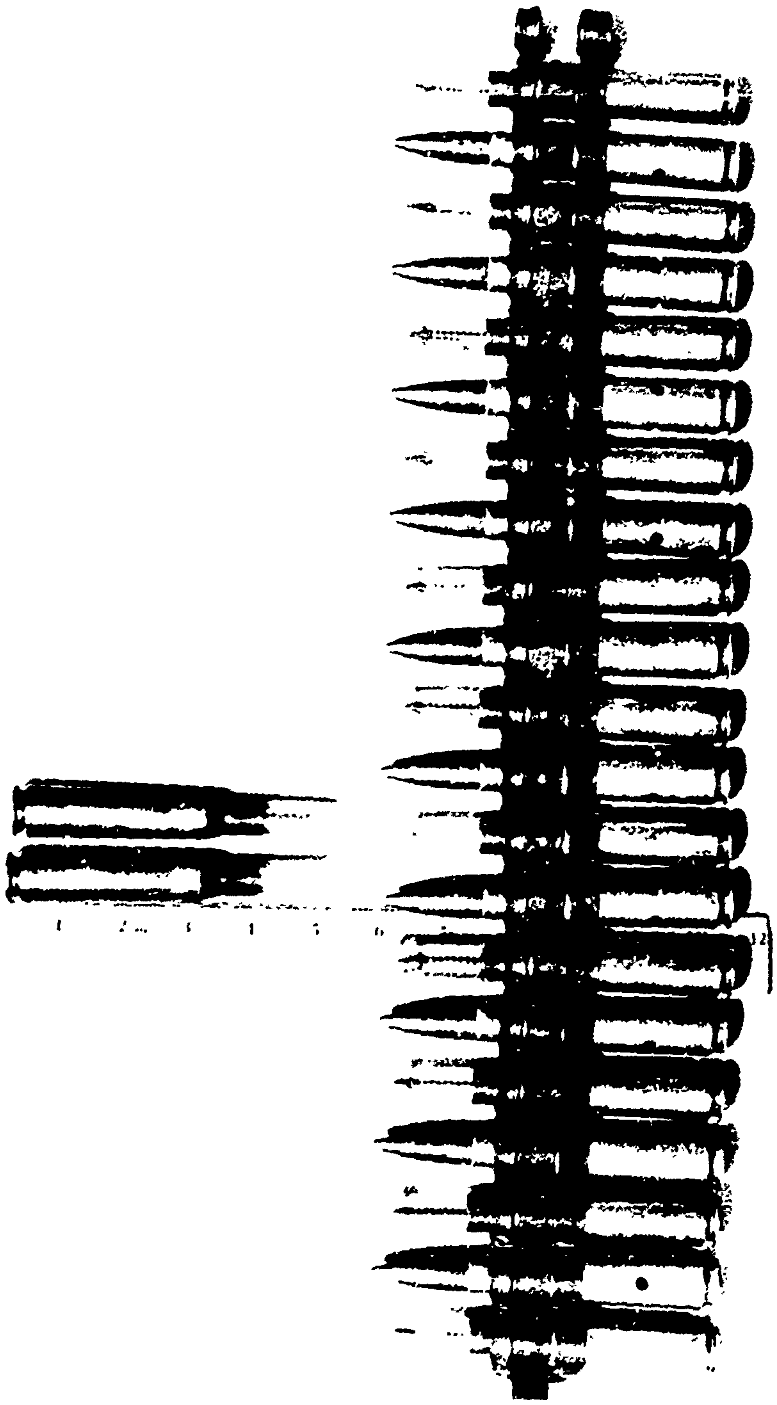
2.6 16 mm Motion Picture Camera

(U) The 16 mm motion picture camera is co-mounted beside the TV camera. A filmed record of the mission is obtained for post-flight evaluation.

(U) The camera is manufactured by Photosonics and operates at a frame rate of 24 to 200 frames per second. It is fitted with a 25 mm to 250 mm zoom lens with a normal aperture of f2.8-22. The focal length is remotely controlled in flight to maintain proper magnification and field of view to document the mission. The on board exposure control unit is automatic.

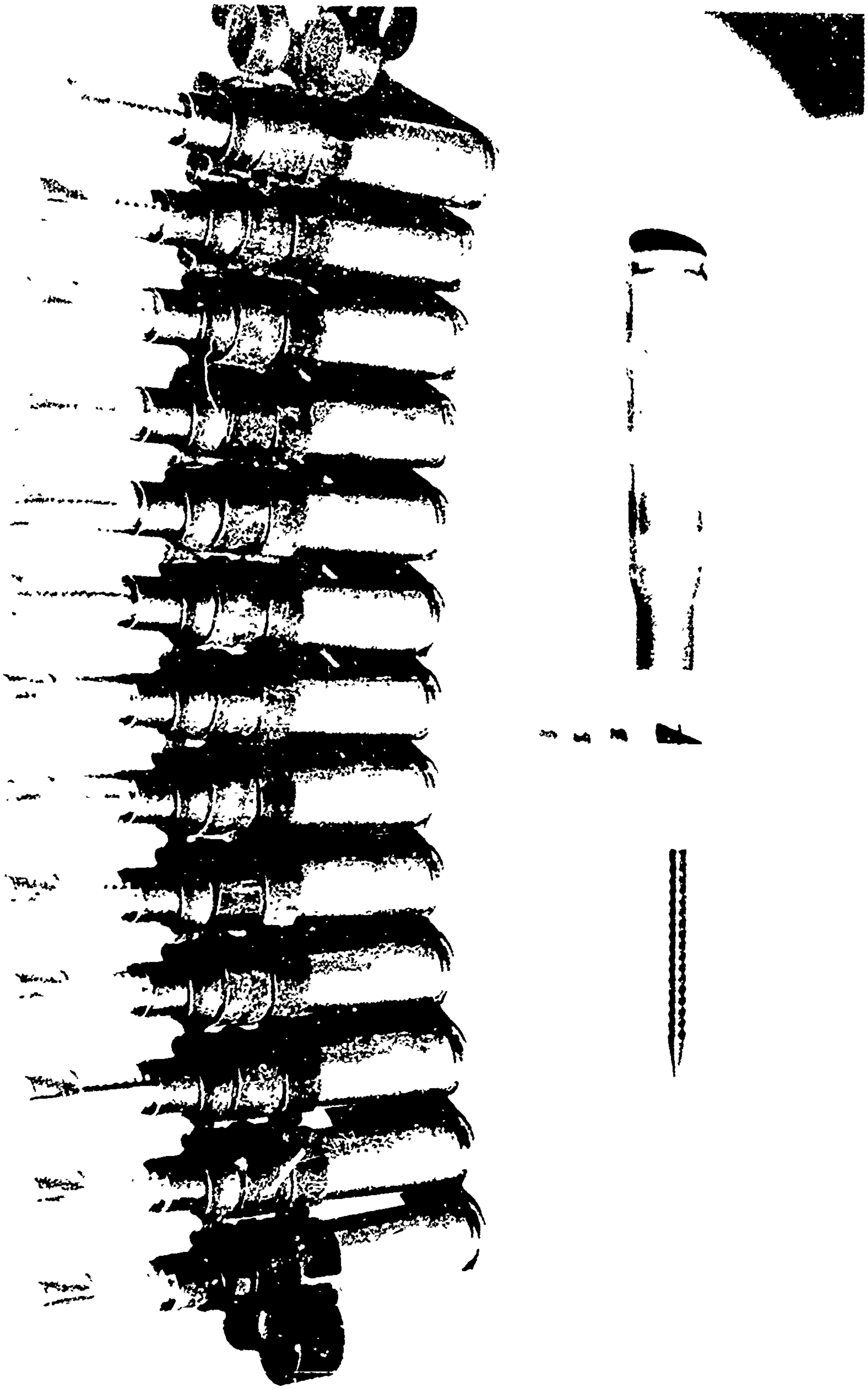
2.7 Laser Illuminator - Ranger

(U) The ILS laser illuminator-ranger is a 14 pound cylindrical unit 4 1/2 inches in diameter and 22 inches long. It operates at a wavelength of 1.06



HV Gun Flechettes Alternating
With Dummy Rounds

Figure A2



HV Gun Flechettes Showing
Sabot Segments
Figure A3

microns, has a pulse width of 15 nanoseconds, and produces 178 millijoules per pulse. Operating frequency is single shot, one pulse per second or ten pulses per second. It has an effective range of 10 kilometers with a ranging accuracy of ± 5 meters.

2.8 Contrast Tracker/Fire Control Computer

(U) The Contrast Tracker/Fire Control Computer was developed to provide precise aiming and correction signals to a fire control system for the HV Gun. Developmental objectives were: 1) to incorporate an optical contrast tracker with the stabilized gun mount and 945 line TV camera system to permit automatic tracking, and 2) to incorporate a flyable fire control computer into the aimpoint system to provide aimpoint adjustments to correct for projectile ballistics, helicopter velocities and crosswinds.

Contrast Tracker TV Screen Presentation

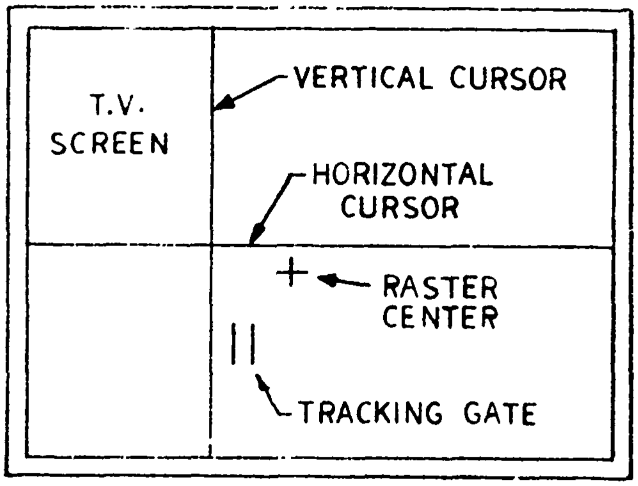


FIGURE A4

(C) In operation, the operator controls the "Big U" mount until a target appears on his TV monitor. He continues to slew the mount until a high contrast edge is positioned within the tracking gate, then the operator switches to "track" mode. See Figure A4. The tracking system will control the mount such that the target appears relatively stationary as the background and field of view change. The electronic cursors move automatically to a new location signifying that the computer has solved the fire control problem. The intersection of the cursors now represents the predicted projectile impact point which is based on target velocity, helicopter velocity, altitude, as well as ballistic constants programmed into the computer such as gravity drop, muzzle velocity and drag coefficients. At this point the operator uses the variable offset controls to reposition the tracking gate so that the desired

impact point on the target, such as the engine block of a truck, is located beneath the intersection of the cursors. After stabilization of the cursors, the weapon may be fired. The operator may at any time regain control of the mount by switching to "cage" mode. He then manually tracks the target by controlling a joy stick to position the cursors on the target.

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR HYPERVELOCITY GUN

Date	Test No.	Plan	Comments
4/21/70	70	Contrast tracker evaluation	Five tracking tests were completed prior to cancellation of the test due to high winds.
4/22/70	70A	Contrast tracker evaluation	Sixteen tracking runs were completed. Tracking errors were measured.
9/2/70	71	Contrast tracker evaluation	Eight tracking runs were completed. Tracking errors were measured.
9/15/70	71A	Contrast tracker evaluation	Eight tracking runs were completed. Tracking errors were measured only on first three runs due to loss of film coverage.
12/2/70	73A	Boresighting	Ten rounds fired and scored in ground boresighting calibration test.
12/3/70	75	Flight Test	Flight aborted due to a misfire.
12/3/70	75	Flight Test	Five rounds fired and scored.
12/4/70	76	Flight Test	Three rounds fired and scored.
2/10/71	242	Boresighting	Testing was terminated after ten rounds because the gun jammed when an empty shell rebounded.
2/22/71	242	Boresighting	Six rounds fired.

Table B-1 Continued

Date	Test No.	Plan	Comments
2/23/71	242	Boresighting	Ten rounds fired.
2/24/71	242	Boresighting	Five rounds fired.
3/24/71	243	Flight Test	Aborted in-flight due to TV reception problem.
3/25/71	243	Flight Test	Aborted in-flight. Temporary malfunction of fire control computer.
3/25/71	243	Flight Test	Aborted in-flight due to cursor movement.
3/25/71	243	Flight Test	Aborted in-flight due to fuel indicator problem.
3/25/71	243	Flight Test	Aborted in-flight due to cursor movement.
4/1/71	-	Hardstand Firings	Diagnostic test with support clamp on gun barrel jacket.
4/8/71	-	Hardstand Firings	Diagnostic test with new bushing and with front barrel brace.
4/12/71	242	Boresighting	HV Gun firings with new bushing and with front barrel brace from helicopter.
4/14/71	242	Boresighting	Nine rounds fired. High dispersion due to flexure in angle iron support of gun barrel clamp.
4/15/71	242	Boresighting	Calibration testing with a new barrel bushing.
4/20/71	243	Flight Test	Aborted in-flight due to gun jam.
4/20/71	243	Flight Test	Aborted in-flight due to intermittent laser ranging.

Table B-1 Continued

Date	Test No.	Plan	Comments
4/23/71	243	Flight Test	Aborted in-flight due to inoperative laser ranger.
4/23/71	243	Flight Test	Aborted in-flight due to no contrast tracker lock.
4/23/71	243	Flight Test	Four rounds fired and scored.
4/26/71	243	Flight Test	Aborted in-flight due to mount control problem.
4/26/71	243	Flight Test	Aborted in-flight due to poor laser ranger readouts.
4/27/71	243	Flight Test	Aborted in-flight due to avionics problem.
5/20/71	243	Flight Test	Ten rounds fired and scored.
11/12/71	-	Hardstand Firings.	Diagnostic testing with shroud.
11/19/71	-	Hardstand Firings	Diagnostic testing with and without shroud.
11/24/71	-	Hardstand Firings	Diagnostic testing without shroud.

APPENDIX C

FLIGHT TEST DATA FOR HYPERVELOCITY GUN

(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

CONTRAST TRACKER EVALUATION
Flight No. - Test No. 70
21 April 1970

(C) This test was conducted for the purpose of collecting baseline data for contrast tracker/mount performance. Five r· .. were completed, then the test was aborted due to high winds. Winds had increased to 30 knots, gusting to 40 knots. Gusty winds and a TV camera problem made contrast tracker lock on difficult. The image vibrated vertically and the illuminated reticle bounced with the background, but the electronic cursors remained steady.

Weather Conditions

Barometric pressure: 26.26" Hg
Temperature: 65° F
Wind: 10 to 15 knots from 20° T

CONTRAST TRACKER EVALUATION
Flight No. - Test No. 70A
22 April 1970

(C) This test was conducted for the purpose of collecting baseline data for contrast tracker/mount performance. Four basic runs were performed in the manual mode with the helicopter at rest on the pad, then repeated in the contrast tracker mode; the gain was reset to maximum steady state condition and all runs were repeated in both modes. Tracking errors were measured on video tape playback.

Weather Conditions

Barometric pressure: 26.70" Hg
Temperature: 64° F
Wind: 6 knots from 270° T

Description of Runs

Run #1 Hold steady on a stationary target at range of 1,000 feet.
Run #2 Track truck moving at 5 mph at a range of 1,000 feet.
Run #3 Track truck moving at 10 mph at a range of 1,000 feet.
Run #4 Track truck moving at 20 mph at a range of 1,000 feet.

Tracking Accuracies (Title Unclassified/Table Confidential)

Run No.	Tracking Mode	Speed of Target	Tracking Error (mils) P.T.P. (1)	Tracking Error (mils) RMS (2)
1	Manual	0 mph	-	-
2	Manual	5 mph	± 2.0	±.8
3	Manual	10 mph	± 1.0	±.5
4	Manual	20 mph	± 2.0	± 1.0
5	Contrast Tracker	0 mph	-	-
6	Contrast Tracker	5 mph	+.5	±.25
7	Contrast Tracker	10 mph	(3)	±.8
8	Contrast Tracker	20 mph	No Lock On (4)	

(1) Peak to Peak
(2) Root-mean-square
(3) Decreased from ±4 mils at beginning to ±.8 mil
(4) Mount could not keep up with tracking gate.

Run No. 8 was rerun several times.

1st rerun - increased video gain; no lock on
2nd rerun - no lock on until truck stopped
3rd rerun - lock on using wide angle lens
4th rerun - lock on near end of run only
5th rerun - lock on on stationary target at start, then truck accelerated to 20 mph. Tracking error was measured at ±.5 foot root-mean-square.

All runs were repeated. (Table Confidential)

Run No.	Tracking Mode	Speed of Target	Tracking Error (mils) P.T.P. (1)	Tracking Error (mils) RMS (2)
1	Manual	0 mph	-	-
2	Manual	5 mph	+1.0	+1.0
3	Manual	10 mph	±2.0	±1.0
4	Manual	20 mph	(3)	
5	Contrast Tracker	0 mph	-	-
6	Contrast Tracker	5 mph	±1.0	±.5
7	Contrast Tracker	10 mph	+.5	±.5
8	Contrast Tracker	20 mph	(4)	

(1) Peak to Peak
(2) Root-mean-square
(3) Could not acquire track due to low mount slew rate.
Run 4 rerun achieved ±1.0 mil RMS tracking error.
(4) Oscillation rate of two hertz; tracking error was ±1.0 mil RMS.

CONTRAST TRACKER EVALUATION
Flight No. - Test No. 71
2 September 1970

(C) This test was conducted for the purpose of collecting baseline data for contrast tracker/mount performance. Four basic runs were performed in the manual mode with the helicopter at rest on the pad, then repeated in the contrast tracker mode. Tracking errors were measured on video tape playback.

Description of Runs

Run #1 Hold steady on stationary target at range of 1,000 feet.
Run #2 Track truck moving at 5 mph at a range of 1,000 feet.
Run #3 Track truck moving at 10 mph at a range of 1,000 feet.
Run #4 Track truck moving at 20 mph at a range of 1,000 feet.

Tracking Accuracies (Title Unclassified/Table Confidential)

Run No.	Tracking Mode	Speed of Target	Tracking Error (mils) P. T. P. (1)	Tracking Error (mils) RMS (2)
1	Manual	0 mph	(3)	(3)
2	Manual	5 mph	(3)	(3)
3	Manual	10 mph	(3)	(3)
4	Manual	20 mph	(3)	(3)
5	Contrast Tracker	0 mph	±.4	±.3
6	Contrast Tracker	5 mph	±.5	±.3
7	Contrast Tracker	10 mph	±.6	±.4
8	Contrast Tracker	20 mph	(4)	(4)

(1) Peak to Peak
(2) Root-mean-square
(3) Not measured
(4) Tracked window on truck - tracking error could not be measured.

All runs were successful except Run #8 which was rerun with the contrast tracker locked on the rear window of the truck cab. It was noted to be easier to lock on a window or metal door than to lock on the target board.

CONTRAST TRACKER EVALUATION
Flight No. - Test No. 71A
15 September 1970

(C) This test was conducted for the purpose of collecting baseline data for contrast tracker/mount performance. Four basic runs were performed in the manual mode with the helicopter at rest on the pad, then repeated in the

contrast tracker mode. No video tape was available, so tracking errors were measured from film coverage of Runs 6, 7 and 8. There was no film coverage on the other runs.

Description of Runs

Run #1 Hold steady on stationary target at range of 1,000 feet.
Run #2 Track truck moving at 5 mph at a range of 1,000 feet.
Run #3 Track truck moving at 10 mph at a range of 1,000 feet.
Run #4 Track truck moving at 20 mph at a range of 1,000 feet.

Tracking Accuracies (Title Unclassified/Table Confidential)

Run No.	Tracking Mode	Speed of Target	Tracking Error (mils) P. T. P. (1)	Tracking Error (mils) RMS (2)
6	Contrast Tracker	5 mph	±.15	±.15
7	Contrast Tracker	10 mph	±.2	±.2
8	Contrast Tracker	20 mph	±.75	±.45

(1) Peak to Peak
(2) Root-mean-square

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 73A
2 December 1970

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. The helicopter was on the launch pad, auxiliary power on, engine power off. A set of six rounds was fired singly at a bull's-eye target 1,500 feet from the gun. The electronic cross hairs and the projected reticle were adjusted to the centroid of the impacts. A set of four rounds was fired yielding a centroid offset 4 inches up and 5 1/2 inches left. The total dispersion was 1.00 mil.

Round Impacts (before boresighting) (Title Unclassified Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	-18	+33
2	0	+15
3	- 6 1/2	+ 9 1/2
4	Missed 4' x 4' target	
5	-7	- 8
6	Missed 4' x 4' target	

Round Impacts (after boresighting) (Title Unclassified
Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
7	+ 7	-13
8	-15	+15
9	-10	-10
10	- 4	+23 1/2

Centroid (last 4 rounds)

$\bar{x}$ = -5 1/2 inches
$\bar{y}$ = +4 inches

Dispersion (8 rounds)

S_x = .44 mil
S_y = .90 mil
S_r = 1.00 mil

FLIGHT TEST
Flight No. 1 Test No. 75
3 December 1970

(C) This test was conducted for the purpose of assessing HV Gun performance under flight conditions against a stationary target using single round firings. The fire control computer and laser range finder were not yet installed.

(C) This test was aborted in flight due to a misfire. All rounds were charged through the gun without firings. Dust was found in the gun mechanism which caused the misfire. During flight the contrast tracker would not lock on the target. When it did lock on momentarily, the mount did not follow, however nothing was found wrong with the contrast tracker or the servo. Flight duration was forty-two minutes.

Weather Conditions

Barometric pressure: 26.8" Hg
Temperature: 55° F
Wind: low and variable

FLIGHT TEST
Flight No. 2 Test No. 75
3 December 1970

(C) This test was terminated after firing four rounds due to fuel shortage. The fifth round was fired the following day, 4 December, prior to Test No. 76 testing. The five rounds were singly fired at a helicopter altitude of 1,000 feet and range of 1,500 feet. The helicopter ground speed was less than 10

knots. The centroid of the impacts was 16.6 inches right and 1.6 inches down. Radial dispersion was 3.08 mils. The scoring crew reported that the projectiles passed through the wooden target and penetrated the truck behind the target, including the cab, fuel tank and tire. The fuel tank contained gasoline, but did not ignite. Flight duration was seventy minutes.

Weather Conditions

Barometric pressure: 26.8" Hg
Temperature: 55° F
Wind: low and variable

Miss Distances (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	- 9	-10
2	-30	-33
3	+17	+44
4	+23	-36
5	+82	+27

Centroid

$\bar{x}$ = +16.6 inches
$\bar{y}$ = - 1.6 inches

Dispersion

S_x = 2.34 mils
S_y = 1.99 mils
S_r = 3.08 mils

FLIGHT TEST
Flight No. 3 Test No. 76
4 December 1970

(C) This flight test was conducted for the purpose of assessing HV Gun performance under flight conditions against a stationary target using single round firings. The fire control computer and laser range finder were not yet installed.

(C) Three rounds were fired at an altitude of 1,000 feet and range of 2,000 feet. The flight was terminated because the range time allotment had expired. The centroid of the impacts was 30.7 inches right and 23.7 inches down. Radial dispersion was 3.80 mils. Analysis of the telemetry records indicates the vehicle was not completely settled out from the last received command when the firings took place. The various horizontal and vertical movements of the helicopter caused adverse effects on the firing. Flight duration was twenty-six minutes.

CONFIDENTIAL

Weather Conditions

Barometric pressure: 26.75" Hg
Temperature: 58° F
Wind: 10 knots at 180° T

Miss Distances (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	-60	-11
2	+50	+64
3	+102	+18

Centroid

$\bar{x}$ = 30.7 inches
$\bar{y}$ = 23.7 inches

Dispersion

S_x = 3.46 mils
S_y = 1.58 mils
S_r = 3.80 mils

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
10 February 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. The helicopter was on the launch pad, auxiliary power on, engine power off. A set of eight rounds was fired at a bull's-eye target 1,500 feet from the gun. Three of the eight firings missed the target and a fourth jammed. The other four rounds were scored to compute a centroid. The gun scope was used to position the gun on the bull's-eye. The mount was locked into position. The gun scope was moved to the centroid and the mount was repositioned to place the gun scope on the bull's-eye. TV camera raster illuminated reticle and electronic cursors were all zeroed on the bull's-eye. Two more rounds were fired, then the gun jammed due to an empty shell rebounding. Testing was terminated.

Round Impacts (before boresighting) (Title Unclassified Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
3	-21	+50
4	-11	+50
6	+72	+55
7	-72	+55

CONFIDENTIAL

CONFIDENTIAL

Centroid (Title Unclassified/Table Confidential)

$\bar{x}$ = - 8 inches
$\bar{y}$ = +53 inches

Round Impacts (after boresighting) (Title Unclassified Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
9	+ 7	+14 1/2
10	-17	-12

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
22 February 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. The helicopter was on the launch pad, auxiliary power on, engine power off. A set of six rounds was fired, however, the first round could not be scored, since several unmarked bullet holes existed in the target until after the first firing. Radial dispersion was 1.18 mils. The next test was scheduled for 23 February 1971, which required the mount and gun be held in position mechanically for the firings.

Round Impacts (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
2	-29	+49
3	-33	+32
4	-25	+10
5	-29	+ 2
6	-35	+ 2

Centroid

$\bar{x}$ = -30.2 inches
$\bar{y}$ = 19 inches

Dispersion

S_x = .22 mil
S_y = 1.16 mils
S_r = 1.18 mils

CONFIDENTIAL

CONFIDENTIAL

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
23 February 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. The helicopter was on the launch pad auxiliary power on, engine power off. The mount and gun were mechanically held rigidly positioned on the target. The mount servos were de-energized. A set of five rounds was fired; a centroid was computed and marked on the target. The TV reticle, cursors and gun scope were aligned to the centroid. The mount was unclamped. The mount servos and the contrast tracker were energized and another set of rounds was fired. The centroid was 5.3 inches left and 14.1 inches down. The dispersion, both sets, was .88 mil.

Round Impacts (before boresighting) (Titles Unclassified Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	-13 1/2	+ 6
2	-37	+ 6
3	-26	+23
4	-30 1/2	+23
5	-21 1/2	+48 1/2

Centroid

$\bar{x}$ = -25.7 inches
$\bar{y}$ = +21.3 inches

Round Impacts (after boresighting) (Titles Unclassified Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
6	-7 1/4	-16 1/2
7	-5 1/2	+ 7 3/4
8	-1 1/2	-13
9	-5 1/4	-22
10	-7	-27

Centroid

$\bar{x}$ = - 5.3 inches
$\bar{y}$ = -14.1 inches

Dispersion (ten rounds)

S_x = .34 mil
S_y = .81 mil
S_r = .88 mil

CONFIDENTIAL

CONFIDENTIAL

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
24 February 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. The helicopter was on the launch pad, auxiliary power on, engine power off. The optics were aligned to the centroid established on 23 February. Six rounds were fired. The first five were used to compute a centroid. (The sixth round was wild.) The centroid was 13 inches right and 3.7 inches up. Radial dispersion was .96 mil.

Round Impacts (after boresighting) (Titles Unclassified Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	+ 9	- 2 1/2
2	+ 8 1/2	-21 1/4
3	+18 1/4	+12 1/4
4	+23	+16
5	+ 7	+14 1/4

Centroid

$\bar{x}$ = 13.0 inches
$\bar{y}$ = 3.7 inches

Dispersion

S_x = .39 mil
S_y = .87 mil
S_r = 96 mil

FLIGHT TEST
Flight No. 4 Test No. 243
24 March 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight due to TV reception problems. Flight duration was thirteen minutes.

Weather Conditions

Barometric pressure: 26.50" Hg
Temperature: 78° F
Wind: 9 knots from 320° T

CONFIDENTIAL

CONFIDENTIAL

FLIGHT TEST
Flight No. 5 Test No. 243
25 March 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight in order to refuel. The fire control computer did not appear to be working on the first run. The helicopter was vectored toward the pad in order to check the computer. The computer began working again before the helicopter landed, so the helicopter was directed out for a live firing. One round was fired into the ground to clear the gun. Flight duration was forty minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 74° F
Wind: 7 to 9 knots from 120° T

FLIGHT TEST
Flight No. 6 Test No. 243
25 March 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using the single round firings.

(C) This test was aborted in flight due to cursor movement in rapid step functions. Flight duration was twenty-four minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 78° F
Wind: 7 to 9 knots from 120° T

FLIGHT TEST
Flight No. 7 Test No. 243
25 March 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight due to a fuel indicator problem. Flight duration was seven minutes.

CONFIDENTIAL

Weather Conditions

Barometric pressure: 26.48" Hg
Temperature: 77° F
Wind: 8 knots from 120° T

FLIGHT TEST
Flight No. 8 Test No. 243
25 March 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight due to up and down cursor movement. Flight duration was thirty minutes.

Weather Conditions

Barometric pressure: 26.48" Hg
Temperature: 77° F
Wind: 8 knots from 120° T

HARDSTAND FIRINGS
1, 8 April 1971

(U) The HV Gun was dismounted from Drone DS-1721 and clamped to a gun stand to test a series of modifications. Also, it was desired to test the gun under ideal conditions to verify the reputed accuracy of the gun and to simplify the evaluation of the modifications to be tested.

(C) Testing began 1 April 1971. Five rounds were fired with the support clamp on the gun barrel jacket at the front of the gun fixture (about 19 inches from the end of the barrel). The clamp was intended to restrain barrel vibration. Radial dispersion for four of the five rounds was 1.13 mils. The clamp was removed and five more rounds were fired. Radial dispersion for the best four rounds was .48 mil. Better accuracy was attained with the clamp off. Testing continued on 8 April. A front barrel brace was installed to rigidly secure the front of the barrel jacket. Ten rounds were fired, however the boresight was adjusted after the first two firings which made them unusable in the analysis. Radial dispersion was 1.13 mils. The front barrel brace was removed and ten rounds were fired. Radial dispersion was 1.08 mils. Comparison of these two sets of firings was inconclusive. A new bushing was installed to decrease the play between the barrel and the barrel jacket. The new bushing decreased the tolerance from between .008

to .01 inch down to .005 inch. The front brace was left off. Seven rounds were fired allowing barrel vibration to damp out after charging each round. Radial dispersion was .47 mils. The front brace was reinstalled and seven rounds were fired. Radial dispersion was .66 mils. Comparison of dispersion shows the best accuracy was attained with the new bushing and no brace. Thirty-four rounds were fired during the hardstand tests. Three rounds were not used in the computation of dispersion due to especially high deviation. Six other rounds were noted as having tumbled, observable due to the elongated bullet hole left in the target. This is strong evidence that defective flechettes are affecting the accuracy of the gun. In addition, tumbling flechettes, having less penetration, reduce the effectiveness of the weapon.

Round Impacts (with clamp and old bushing) (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	Missed Target	
2	+10	+22 1/2
3	+ 1	+42 1/2
4	-12	+30 1/2
5	-27	+12 3/4

Centroid (excluding Round No. 1)

$\bar{x} = -7$ inches
$\bar{y} = +27$ inches

Dispersion (excluding Round No. 1)

$S_x = .89$ mil
$S_y = .70$ mil
$S_r = 1.13$ mils

Round Impacts (clamp removed and old bushing) (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
6	-20	-1/2
7	+31 1/2	+12
8	- 8	+11
9	-17	+15
10	-11	+ 6

Centroid (excluding Round No. 7)

$\bar{x} = -14$ inches
$\bar{y} = +8$ inches

Dispersion (excluding Round No. 7)

$S_x = .30$ mil
$S_y = .37$ mil
$S_r = .48$ mil

Round Impacts (front barrel brace and old bushing) (Titles Unclassified
Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
3	+19	+18 1/2
4	+23	-10
5	+30 1/4	- 1
6	+23	+11 1/2
7	+34	+19 1/2
8	+25	0 (tumbled)
9	- 6 1/2	+15 (tumbled)
10	+29	-26 1/4

Centroid

$\bar{x}$ = 22.1 inches
$\bar{y}$ = 3.4 inches

Dispersion

S_x = .69 mil
S_y = .89 mil
S_r = 1.13 mils

Round Impacts (front brace removed and old bushing) (Titles Unclassified
Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
11	+23	-28
12	+35	-29 1/2
13	+33 1/2	-22 3/4
14	-44 1/2	- 4
15	+17	- 7 3/4 (tumbled
16	+17	- 5 (tumbled)
17	+32 3/4	+11
18	+24	+ 6 1/2
19	+30 1/4	-18
20	+42 1/2	-42 1/4

Centroid

$\bar{x}$ = 30 inches
$\bar{y}$ = -14 inches

Dispersion

S_x = .53 mil
S_y = .94 mil
S_r = 1.08 mils

Round Impacts (new bushing and no front brace)
(Title Unclassified/Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
21	+19 3/4	-7 3/4
22	+26 1/4	-6 1/4

Round No.	Delta x (inches)	Delta y (inches)
23	+26	- 8
24	+27 3/4	-16 3/4
25	+26	-20
26	+18	-19 1/2
27	+23	-25 1/2

Centroid

$\bar{x}$ = 23.8 inches
$\bar{y}$ = -14.8 inches

Dispersion

S_x = .21 mil
S_y = .42 mil
S_r = .47 mil

Round Impacts (new bushing and front brace reinstalled) (Titles Unclassified Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
28	+ 9 3/4	- 6 1/2
29	+19	- 9 1/2
30	+20	- 1/2
31	+19 1/4	+ 3
32	+27 1/2	- 7 1/2
33	+32 3/4	+14 (tumbled)
34	+40 1/4	-68

Centroid (excluding Round No. 34)

$\bar{x}$ = 21.4 inches
$\bar{y}$ = -1.2 inches

Dispersion (excluding Round No. 34)

S_x = .44 mil
S_y = .49 mil
S_r = .66 mil

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
12 April 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cursors. A new gun brace was installed with a clearance of .003 inches between the cooling jacket and the brace flange. The new gun barrel bushing was installed. The helicopter was on the launch pad, auxiliary power on, engine power off. The mount was mechanically held on the bull's-eye. Four rounds were fired at a bull's-eye target 1,500 feet

away in order to adjust the gun barrel. It was noted that the mechanical system which held the gun and mount on target was not working. The gun moved after each round. The contrast tracker was used to position and control the mount. Seven rounds were fired. Radial dispersion was .85 mil.

Round Impacts (before boresighting) (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
5	+42	- 3
6	+37 1/2	+11
7	+40	+11
8	+34	+26
9	+39 1/2	+26
10	+41	+36
11	+26	+33

Centroid	Dispersion
$\bar{x}$ = 37 inches	S_x = .33 mil
$\bar{y}$ = 20 inches	S_y = .78 mil
	S_r = .85 mil

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
14 April 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cursors. The helicopter was at rest on the launch pad, auxiliary power on, engine power off. All systems were boresighted using the centroid established on 12 April as a reference.

(C) Nine rounds were fired at a bull's-eye target 1,500 feet from the helicopter. Dispersion was high (1.23 mils), attributed to flexure in the angle iron support (gun barrel clamp) during firing. A burst firing was attempted to evaluate the effect on the mount and contrast tracker. The contrast tracker lost lock after the first round due to smearing of the TV video. Radial dispersion was 2.18 mils.

Round Impacts (after boresighting) (Title Unclassified/Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	-21 1/2	-28
2	-3 1/2	+20 1/2

Round Impacts (after boresighting) (cont) (Table Confidential)

Round No.	Delta x (inches)	Delta y (inches)
3	+18	-28 1/2 (tumbled)
4	-17	-16 1/2 (wild/not used in computing dispersion)
5	+25	- 8 1/2
6	+23	- 6 1/2
7	+ 8	0
8	+17	- 3 1/2
9	+16 1/2	- 6

Centroid

$\bar{x}$ = 10.3 inches
$\bar{y}$ = -7.6 inches

Dispersion

S_x = .87 mil
S_y = .87 mil
S_r = 1.23 mils

Round Impacts (burst firing) (Titles Unclassified Tables Confidential)

Burst	Delta x (inches)	Delta y (inches)
	+ 8 1/2	-18 (tumbled)
	+15	-44
	-19	- 3 1/2
	-39 1/2	+ 2 1/2
	+ 1 1/2	+12 (tumbled)
	+53	-41 1/2 (tumbled)

Centroid

$\bar{x}$ = 3.25 inches
$\bar{y}$ = -15.5 inches

Dispersion

S_x = 1.75 mils
S_y = 1.30 mils
S_r = 2.18 mils

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 242
15 April 1971

(C) This boresighting and calibration test was conducted for the purpose of aligning the HV Gun with the gun jacket telescope, the projected reticle, and the contrast tracker electronic cross hairs. Another new bushing was installed between the gun barrel and the cooling jacket. The clearance was .005 inches. The helicopter was at rest on the launch pad, auxiliary power on, engine power off.

(C) Seven rounds were fired at a bull's-eye target 1,500 feet from the helicopter. The centroid was computed and marked on the target.

(C) Holding the mount on the previously established aimpoint, the TV camera and TV reticle were moved to the new optical boresight position. The contrast tracker cursors were repositioned. The aimpoint was selected such that the rounds would impact around the bull's-eye and seven rounds were fired. The centroid was computed using only five firings because the aimpoint was incorrect for two firings. The centroid was 2.3 inches left and 5.4 inches down. Radial dispersion, both sets, was .70 mil.

(C) The computer and laser were energized and five rounds were fired. The centroid was 2.75 inches right and 2 inches down. Radial dispersion for this set was .84 mil.

(C) A five round burst was fired. The contrast tracker lost lock due to TV video smearing after the first round was fired.

Round Impacts (before boresighting) (Titles Unclassified Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	+ 6 3/4	-10 1/2
2	+12	-18 1/4
3	+ 9 1/4	-22 1/2
4	+ 4 1/2	-25 1/2
5	+ 2 1/4	-20 3/4
6	-1/2	-24 1/2
7	+18 1/2	-51 (tumbled)

Centroid (not including Round No. 7)

$\bar{x}$ = 5.7 inches
$\bar{y}$ = -20.3 inches

 CONFIDENTIAL

Round Impacts (after boresighting) (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
10	+ 1 1/2	-15
11	+ 2	- 8
12	+ 9 1/2	+ 2 1/2
13	- 1	+13 1/2
14	-23 1/2	-20

Centroid

$\bar{x}$ = -2.3 inches
$\bar{y}$ = -5.4 inches

Dispersion (11 rounds)

S_x = .47 mil
S_y = .52 mil
S_T = .70 mil

Round Impacts (computer and laser energized) (Titles Unclassified/Tables Confidential

Round No.	Delta x (inches)	Delta y (inches)
15	+ 3/4	- 3
16	- 1 3/4	+ 3
17	+ 5 3/4	- 7
18	- 1 1/4	+18
19	+10 1/4	-21

Centroid

$\bar{x}$ = 2.75 inches
$\bar{y}$ = -2 inches

Dispersion

S_x = .29 mil
S_y = .79 mil
S_T = .84 mil

Round Impacts (burst firing) (Titles Unclassified/Tables Confidential

Round No.	Delta x (inches)	Delta y (inches)
	- 3/4	+29 3/4
	+15 1/2	+29 3/4
	+14 1/2	+ 1 1/4
	-56	+16 (tumbled
	+18 3/4	+63

Centroid

$\bar{x}$ = -2 inches
$\bar{y}$ = 27.8 inches

Dispersion

S_x = 1.79 mils
S_y = 1.27 mils
S_T = 2.19 mils

FLIGHT TEST
Flight No. 9 Test No. 243
20 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight after firing one round of SAWS. The second round jammed in the gun. The first round was fired from a range of 680 meters and impacted 7 inches left and .5 inch below the bull's-eye. The contrast tracker maintained lock. Flight duration was thirty minutes.

Weather Conditions

Barometric pressure: 26.42" Hg
Temperature: 72° F
Wind: 20 knots from 150° T

FLIGHT TEST
Flight No. 10 Test No. 243
20 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight because the laser was intermittent in ranging and the mount locked in the stow position. Winds were gusting to 35 knots. Flight duration was twenty-four minutes.

Weather Conditions

Barometric pressure: 26.42" Hg
Temperature: 72° F
Wind: 20 knots from 150° T

FLIGHT TEST
Flight No. 11 Test No. 243
23 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight due to no laser range readouts. Flight duration was twenty-six minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 56° F
Wind: light and variable

FLIGHT TEST
Flight No. 12 Test No. 243
23 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight because contrast tracker lock could not be maintained due to mount vibration while in near hover. Flight duration was twenty-one minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 56° F
Wind: light and variable

FLIGHT TEST
Flight No. 13 Test No. 243
23 April 1971

(C) This flight test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target, single rounds.

(C) This test was conducted at an altitude of 1,000 feet and a ground speed less than 10 knots. Four rounds were fired at a bull's-eye target at varied ranges. The centroid was 13 inches left and 9.5 inches up. Radial dispersion was 1.92 mils. This test was aborted in flight due to TV synchronization problems. Flight duration was forty-one minutes.

Weather Conditions

Barometric pressure: 26.52" Hg
Temperature: 56° F
Wind: 8 knots from 80° T

Miss Distances (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)	Range to Target (meters)
1	-18 1/2	-55 1/2	680
2	-15	+45	630
3	- 7	+45	550
4	-11	+ 3 1/2	460

Centroid

$\bar{x}$ = -13 inches
$\bar{y}$ = 9 1/2 inches

Dispersion

S_x = .16 mil
S_y = 1.91 mils
S_r = 1.92 mils

FLIGHT TEST
Flight No. 14 Test No. 243
26 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) This test was aborted in flight because the mount would not come out of stow. There was no tilt control. Flight duration was five minutes.

Weather Conditions

Barometric pressure: 26.57" Hg
Temperature: 60° F
Wind: light and variable

FLIGHT TEST
Flight No. 15 Test No. 243
26 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target, using single round firings.

(C) This test was aborted in flight after three unsuccessful passes due to poor laser range readouts. No firings were attempted. Flight duration was thirty-one minutes.

Weather Conditions

Barometric pressure: 26.57" Hg
Temperature: 60° F
Wind: 5 knots from 330° T

FLIGHT TEST
Flight No. 16 Test No. 243
27 April 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target, using single round firings.

(C) This test was aborted in flight due to an avionics problem. The yaw axis malfunctioned. Flight duration was two minutes.

Weather Conditions

Barometric pressure: 26.65" Hg
Temperature: 65° F
Wind: calm

FLIGHT TEST
Flight No. 17 Test No. 243
20 May 1971

(C) This test was conducted to assess the performance of the HV Gun under flight conditions against a stationary target using single round firings.

(C) Ten rounds were fired in close succession at a bull's-eye target at a range of 1,500 feet. No scoring was done until all rounds had been fired. The centroid of the impacts was 8.5 inches right and 2.4 inches up. Radial dispersion was 1.00 mil for all rounds, .61 mil excluding those rounds that tumbled.

(C) Error in aimpoint was measured on TV video tape playback using the target board paint pattern to scale the offset between the cross hairs and the bull's-eye at the time of firing. The standard deviation was .31 mil. Difficulty was reported in holding the aimpoint on the bull's-eye due to the helicopter being in hover. Total flight time was thirteen minutes.

Weather Conditions

Barometric Pressure: 26.44" Hg
Temperature: 85° F
Wind: 14 knots out of southeast

Miss Distance (Titles Unclassified/Tables Confidential)

Delta x (inches)	Delta y (inches)
+9	+2
+9	+7 1/4
-2 3/4	+3 3/4
+14 1/2	+1 1/2
+27 1/4	-3
+32 3/4	+7 1/2 *(tumbled)
0	+1
-17	+24 1/2 *(tumbled)
+ 3/4	-2 1/4
+11 3/4	-18 1/4 *(tumbled)

Centroid (all rounds)

$\overline{x}$ = 9.5 inches
$\overline{y}$ = 2.4 inches

Dispersion (all rounds)

S_x = .81 mil
S_y = .59 mil
S_r = 1.00 mil

Centroid (excluding asterisked rounds)

$\overline{x}$ = 8.2 inches
$\overline{y}$ = 1.4 inches

Dispersion (excluding asterisked rounds)

S_x = .57 mil
S_y = .19 mil
S_r = .61 mil

Aiming Error (Titles Unclassified/Tables Confidential)

Round No.	Delta x (inches)	Delta y (inches)
1	+2	-4
2	+2	+11
3	0	-1
4	+3	+3
5	+2	-9
6	-1	-2
7	0	0
8	-1	-5
9	0	0
10	+2	-4

Average	Standard Deviation
$\overline{x}$ = 1 inch	S_x = .08 mil
$\overline{y}$ = -1 inch	S_y = .30 mil
	S_r = .31 mil

HV GUN
HARDSTAND FIRINGS
November 1971

(C) HV Gun Hardstand Firings were again initiated on 12 November 1971 to confirm the .5 mil desired accuracy of the weapon. Previous ARPA hardstand firings in April 1971 indicated that about 20% of the SAWS rounds were defective. On 6 October 1971, it was confirmed that there was indeed a production flaw in the crimping of the fins on the rod. ARPA was advised of the defect and a quick fix correction was attempted by TRW which changes the configuration of the fins. Seventeen thousand rounds were produced. This series of hardstand firings used SAWS rounds from this group.

(C) In order to test the new ammunition, it was necessary to mount the gun in the most stable configuration possible and thus reduce the number of variables in each firing. In other words, if the gun could be held so that the aimpoint was constant, the dispersion of the rounds on the target would be due almost entirely to the ammunition and/or those factors affecting the flight of the projectile after it left the barrel. In order to accomplish this, the gun was first mounted in the normal "cradle", and then this cradle was securely bolted to a heavy steel framework. After this, since the gun was now bolted in place, a target was erected in front of the gun. Finally, a surveyor's transit was sighted through the gun barrel to confirm that the barrel remained oriented along the original axis.

(C) Analysis of the hardstand firing data collected indicates:

1) the gun barrel needs to be cleaned frequently due to plastic "build up",

2) there is still an ammunition problem resulting in wild rounds and tumbling rounds, and

3) the ammunition problem may be accentuated with the shroud on the barrel.

(C) A "build up" of plastic material, from the sabots, occurred in the barrel after some 50 rounds had been fired. A final series of eight sets of firings was conducted after the barrel had been thoroughly cleaned and the results appear to confirm that, in order to achieve the desired accuracy, the barrel must be cleaned thoroughly and frequently.

(C) Twenty-seven of 159 rounds (17%) were either wild or they tumbled. Eighteen of 79 rounds (23%) were bad with the shroud attached while only 9 of 80 rounds (11%) were bad with the shroud removed. The mean dispersion for these hardstand firings, listed below, is .70 mil.

Date	Rounds Fired	Rounds Scored	Range to Target (feet)	Radial Dispersion (mils)	Remarks
11/12/71	9	8	234	.72	Shroud
	15	13	234	.88	Shroud
	10	8	230	.73	Shroud
	10	6	230	.55	Shroud
	10	8	230	.66	Shroud
	10	4	230	.52	Shroud
11/19/71	15	14	1340	1.12	Shroud
	10	9	1340	.55	No shroud Clean barrel
	10	8	1340	.65	No shroud
11/24/71	10	8	1340	.53	No shroud
	10	10	1340	1.03	No shroud
	10	9	1340	.46	No shroud, Clean barrel
	10	10	1340	.31	No shroud
	10	9	1340	.68	No shroud
	10	8	1340	.83	No shroud, New barrel

(Table Confidential)

CONFIDENTIAL

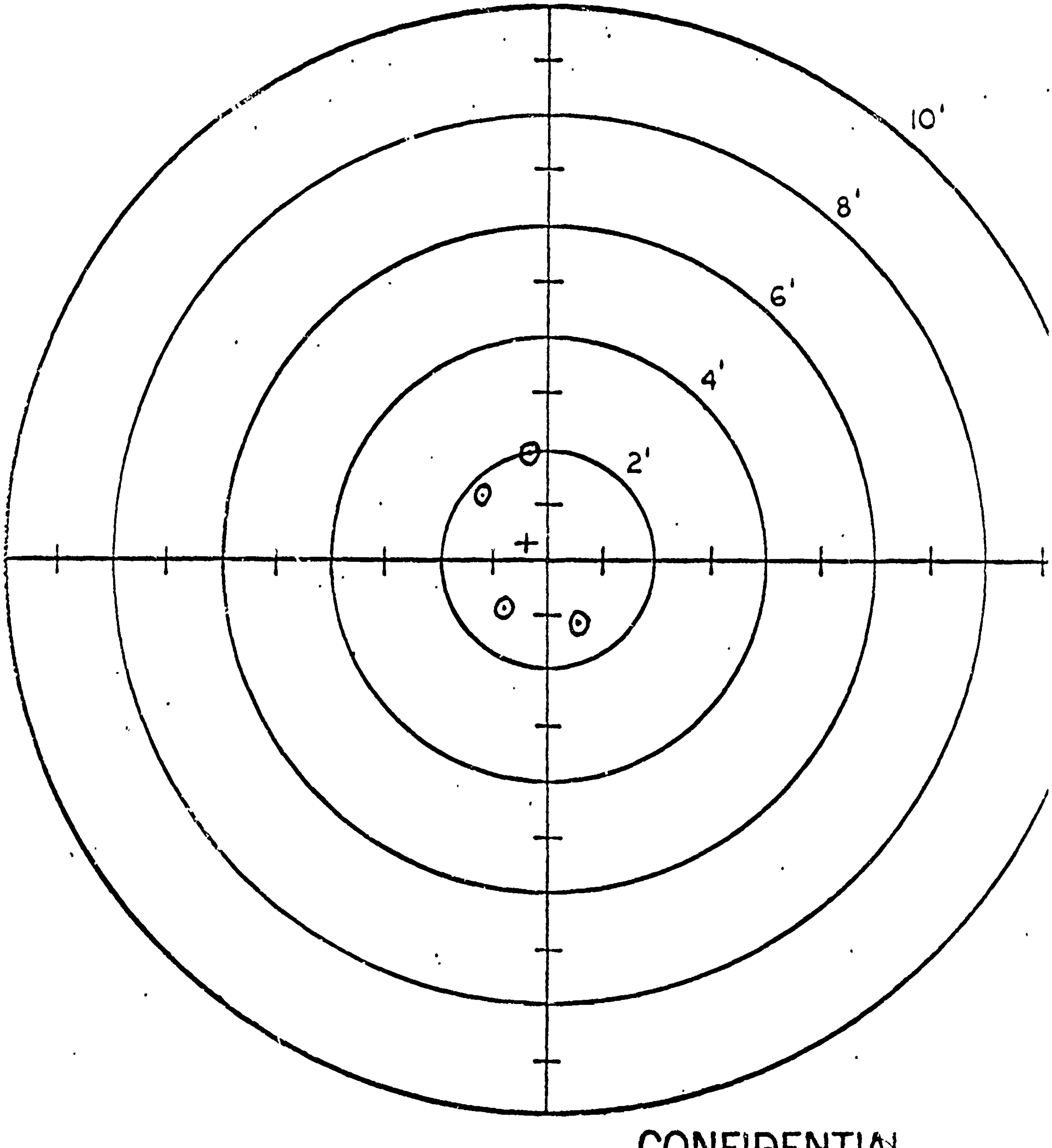
GRAPHS

Test Number 73A

Boresighting and Calibration

CONFIDENTIAL

1 December 1970/2 December 1970



CONFIDENTIAL

+ - Centroid

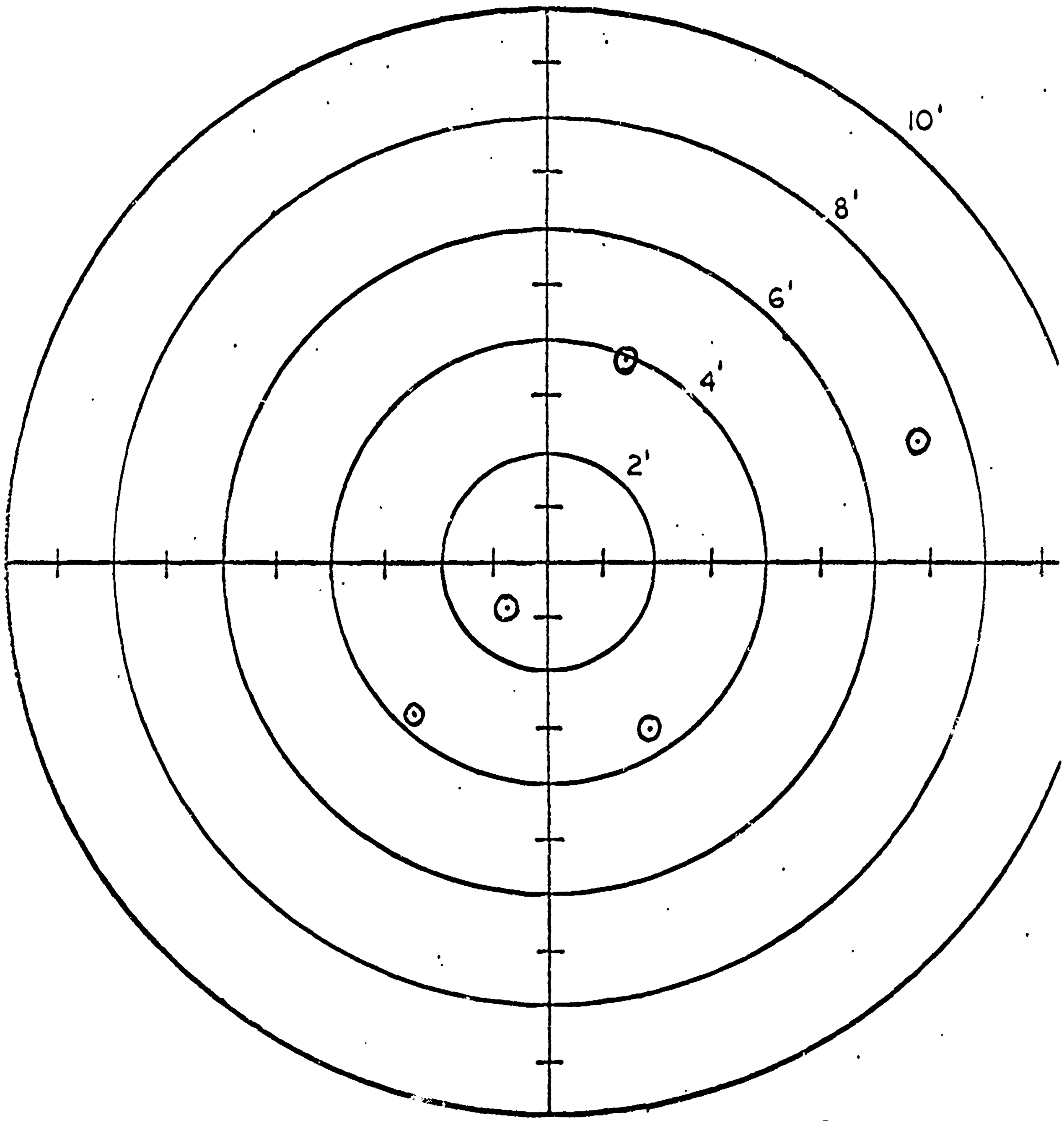
CONFIDENTIAL

Test Number 75

Flight Test

3 December 1970

CONFIDENTIAL



CONFIDENTIAL

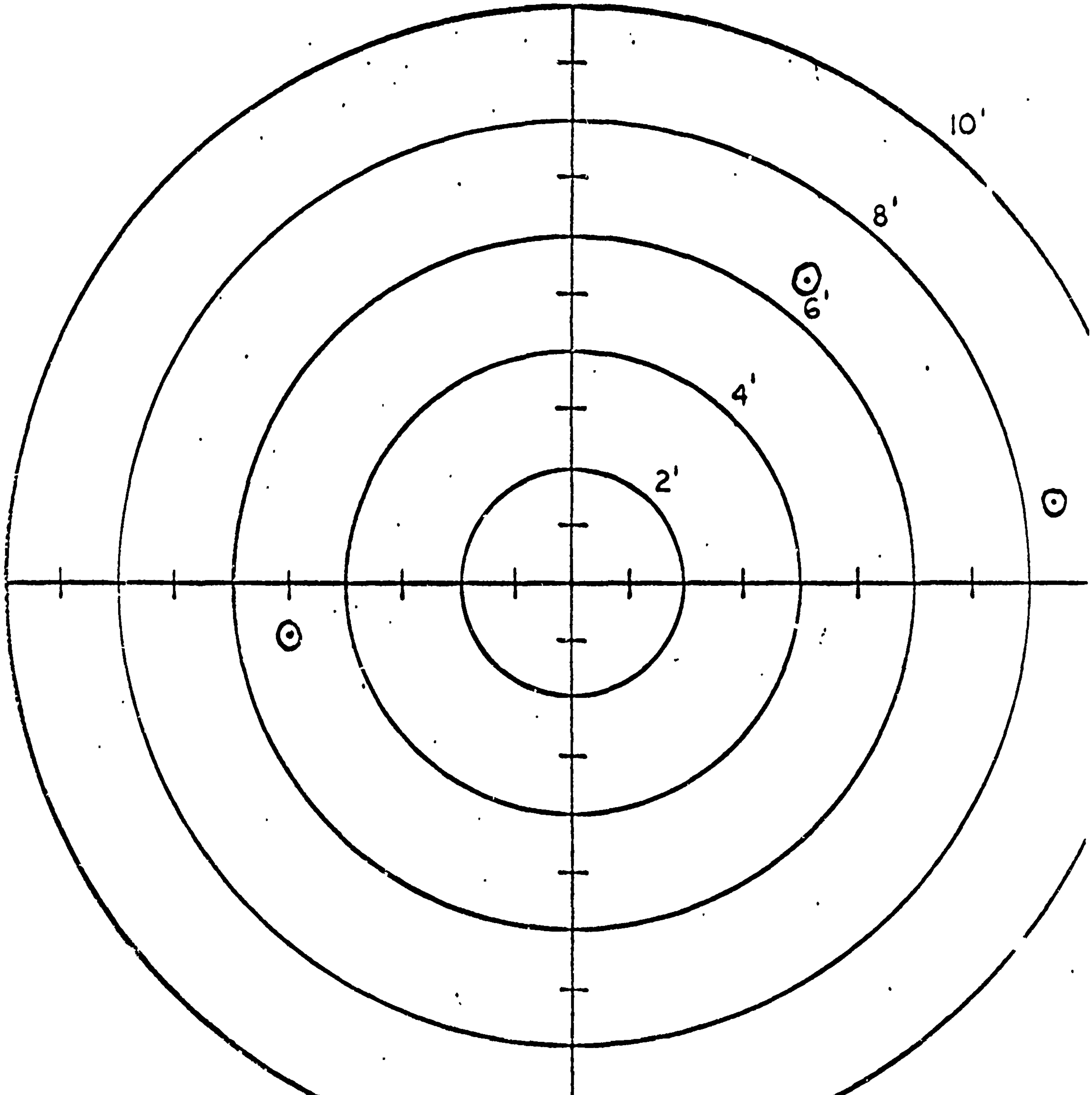
CONFIDENTIAL

Test Number 76

Flight Test

4 December 1970

CONFIDENTIAL



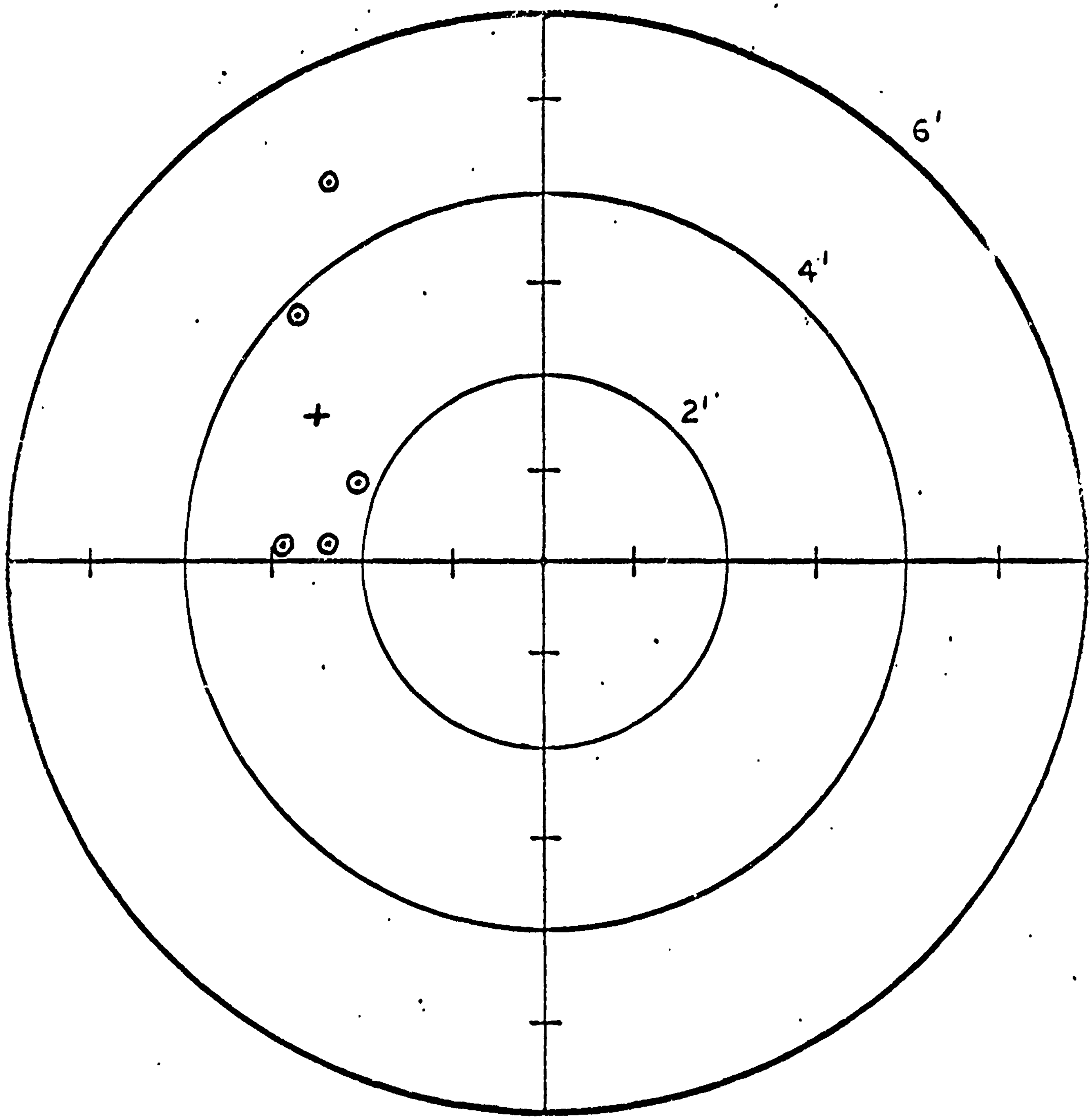
CONFIDENTIAL

Test Number 242

CONFIDENTIAL

Boresighting and Calibration

22 February 1971



+ - Centroid

CONFIDENTIAL

Test Number 242

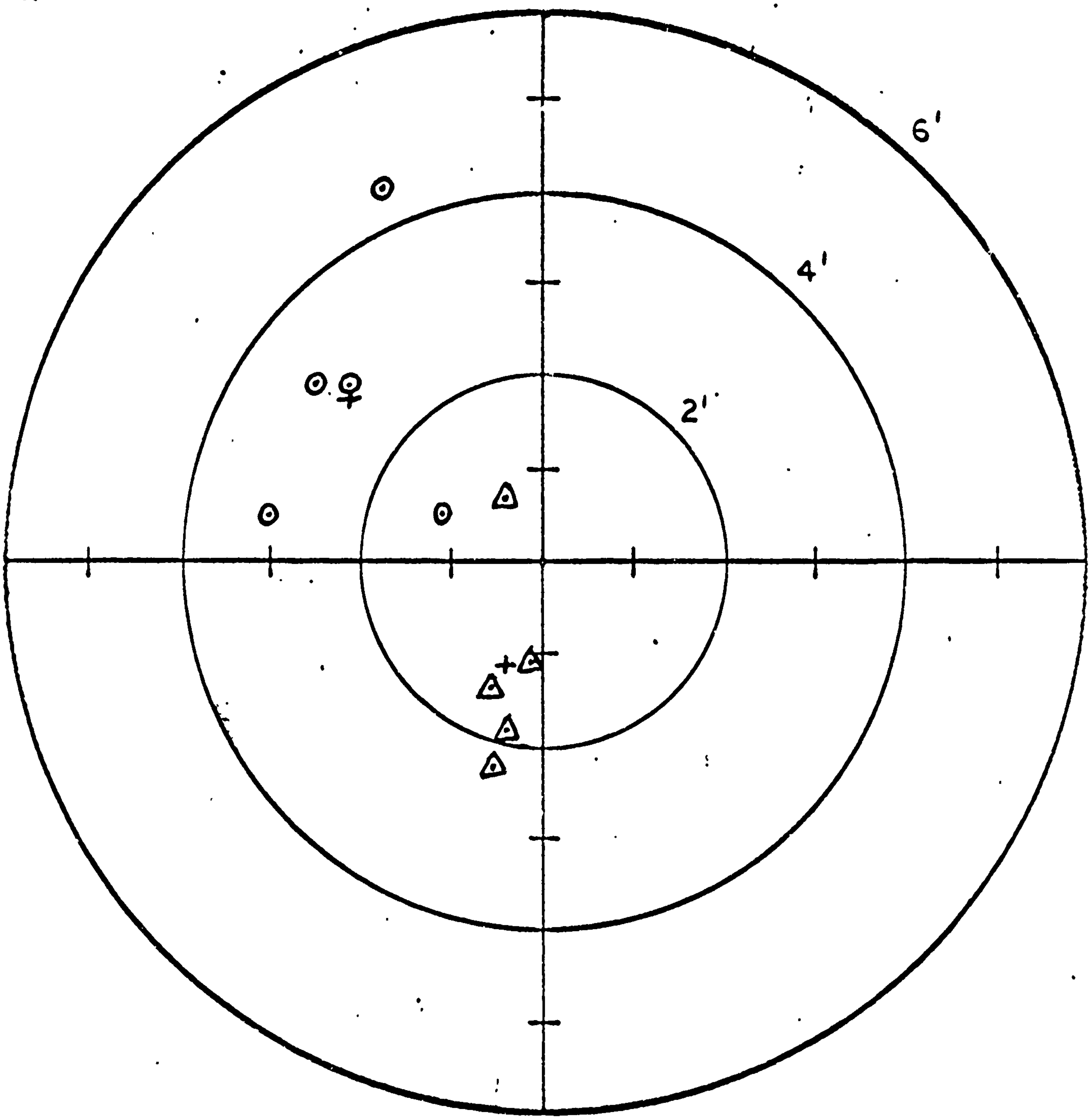
CONFIDENTIAL

Boresighting and Calibration

23 February 1971

⊙ Rounds 20-24

△ Rounds 24-29



+ - Centroid

CONFIDENTIAL

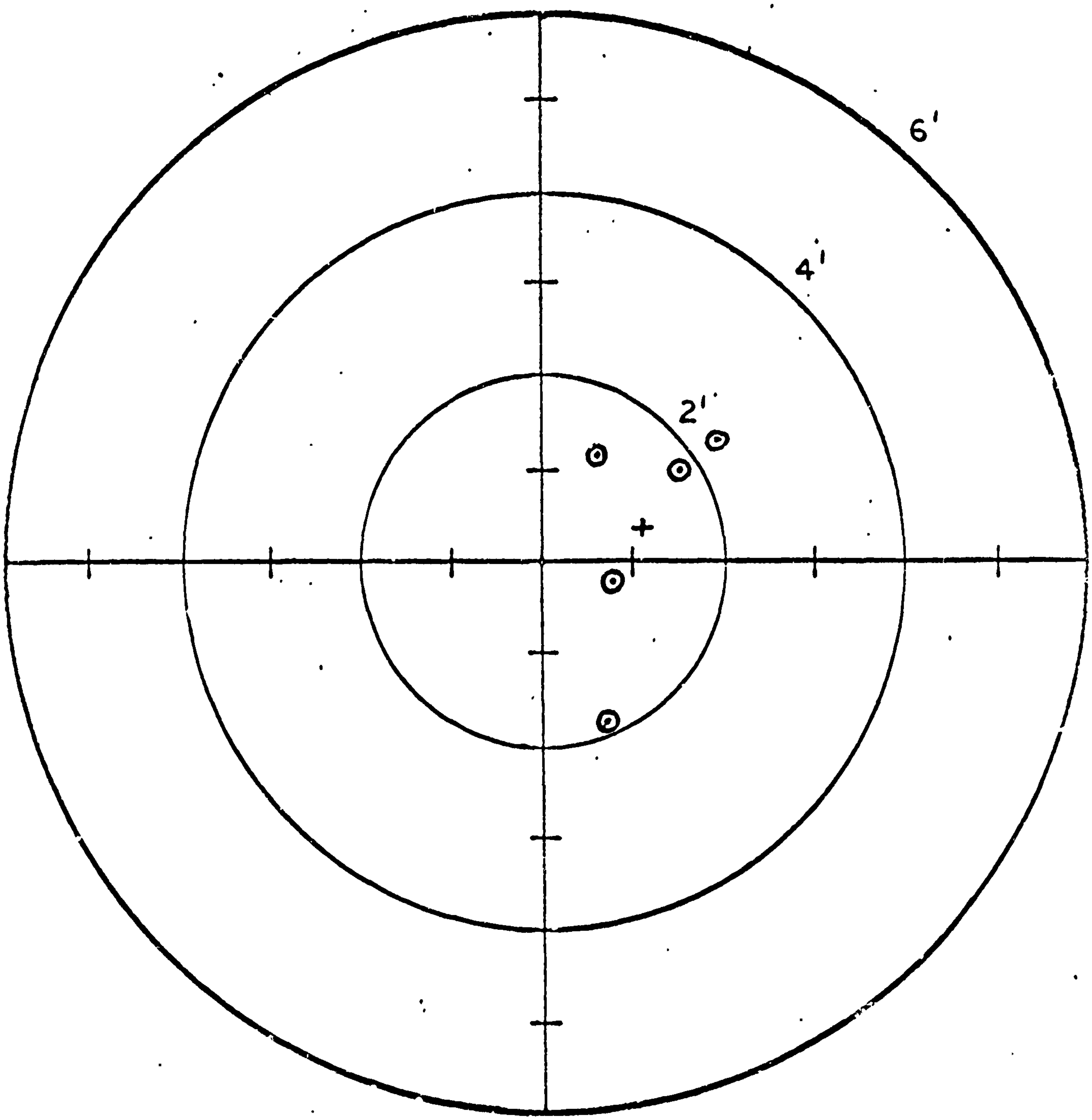
CONFIDENTIAL

Test Number 242

Boresighting and Calibration

24 February 1971

CONFIDENTIAL



+ - Centroid

CONFIDENTIAL

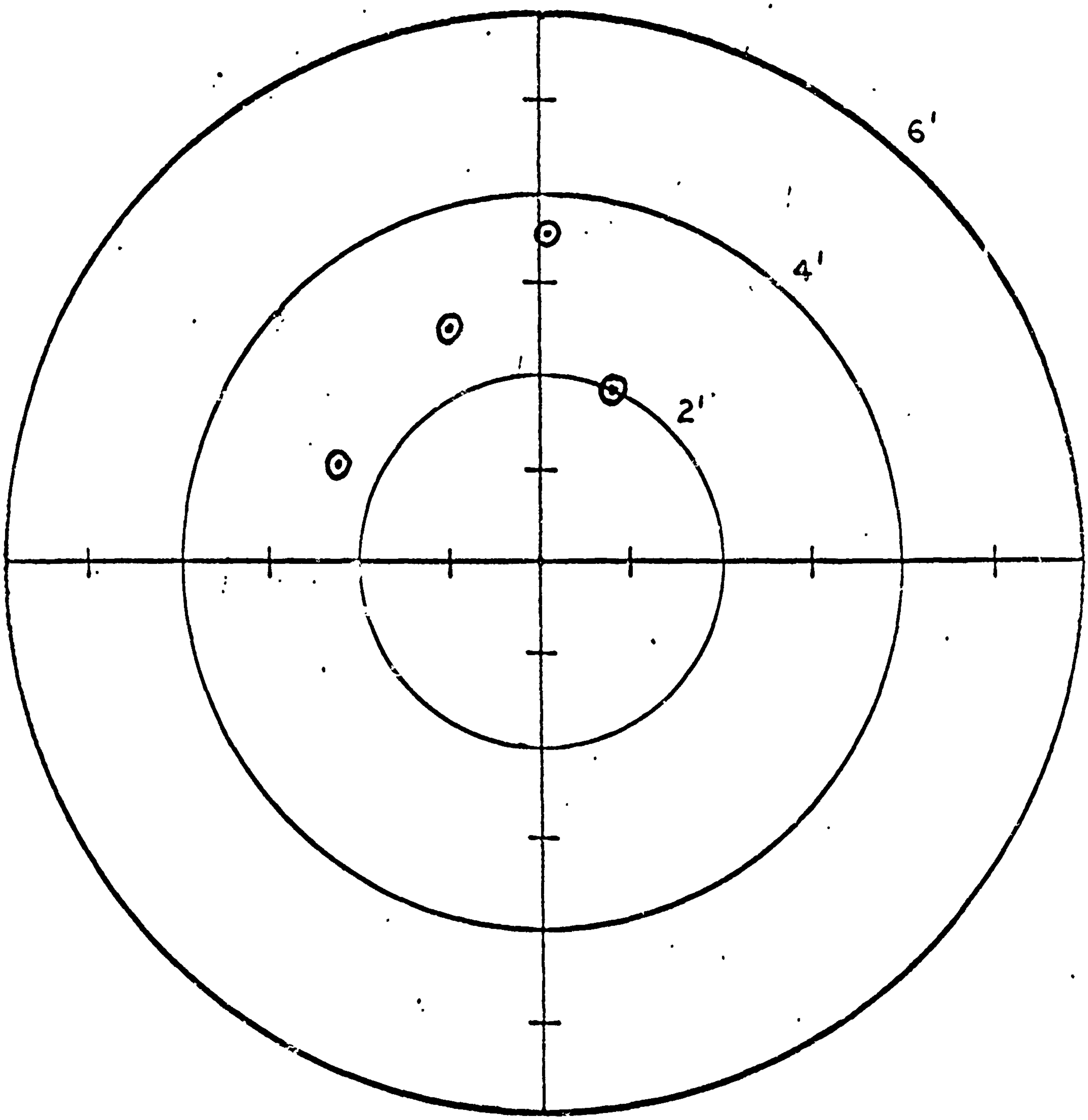
CONFIDENTIAL

Hardstand Firings

Support Clamp on Gun Barrel

1 April 1971

CONFIDENTIAL



One round missed target board

CONFIDENTIAL

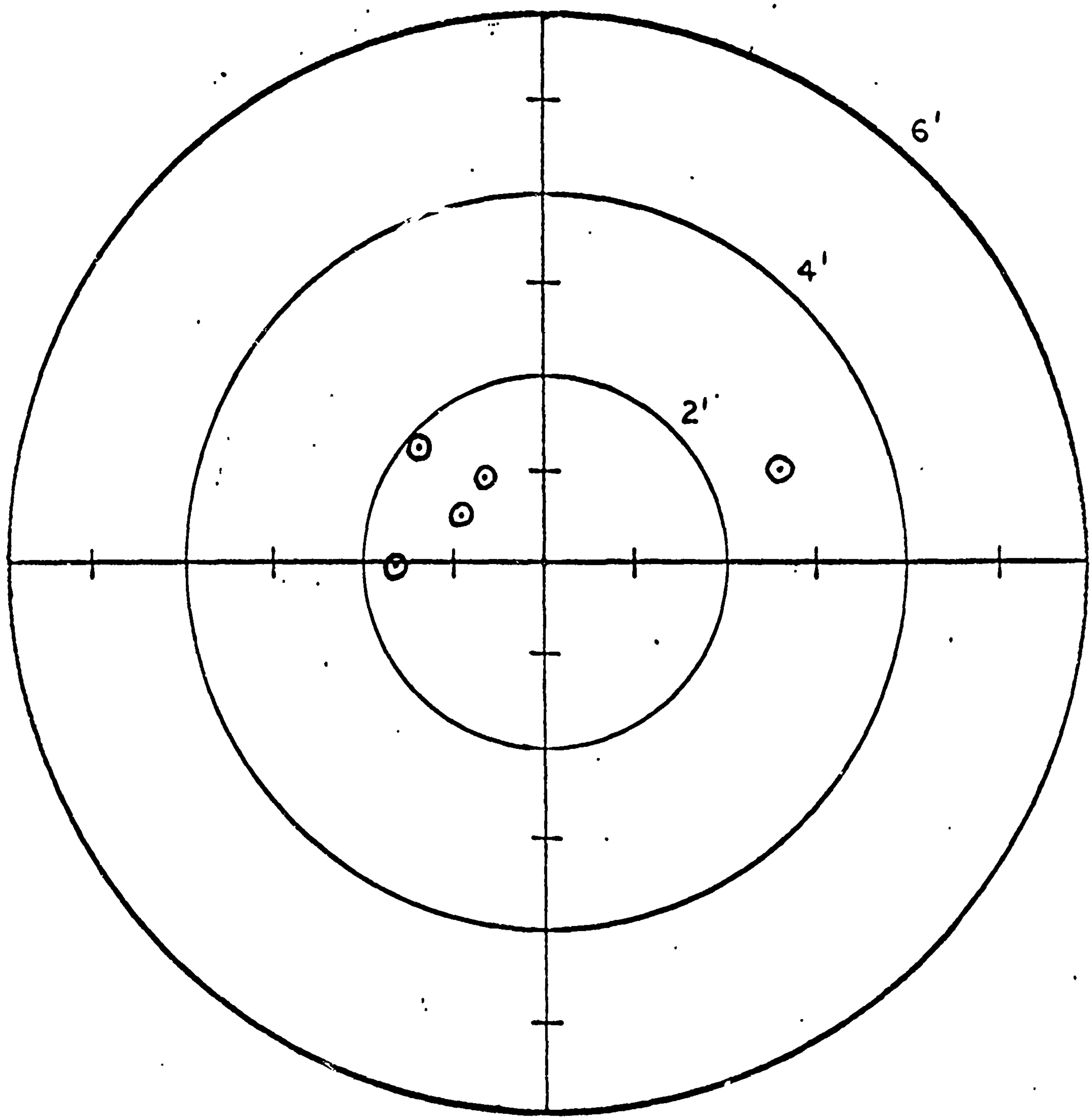
CONFIDENTIAL

Hardstand Firings

Support Clamp Removed

1 April 1971

CONFIDENTIAL



CONFIDENTIAL

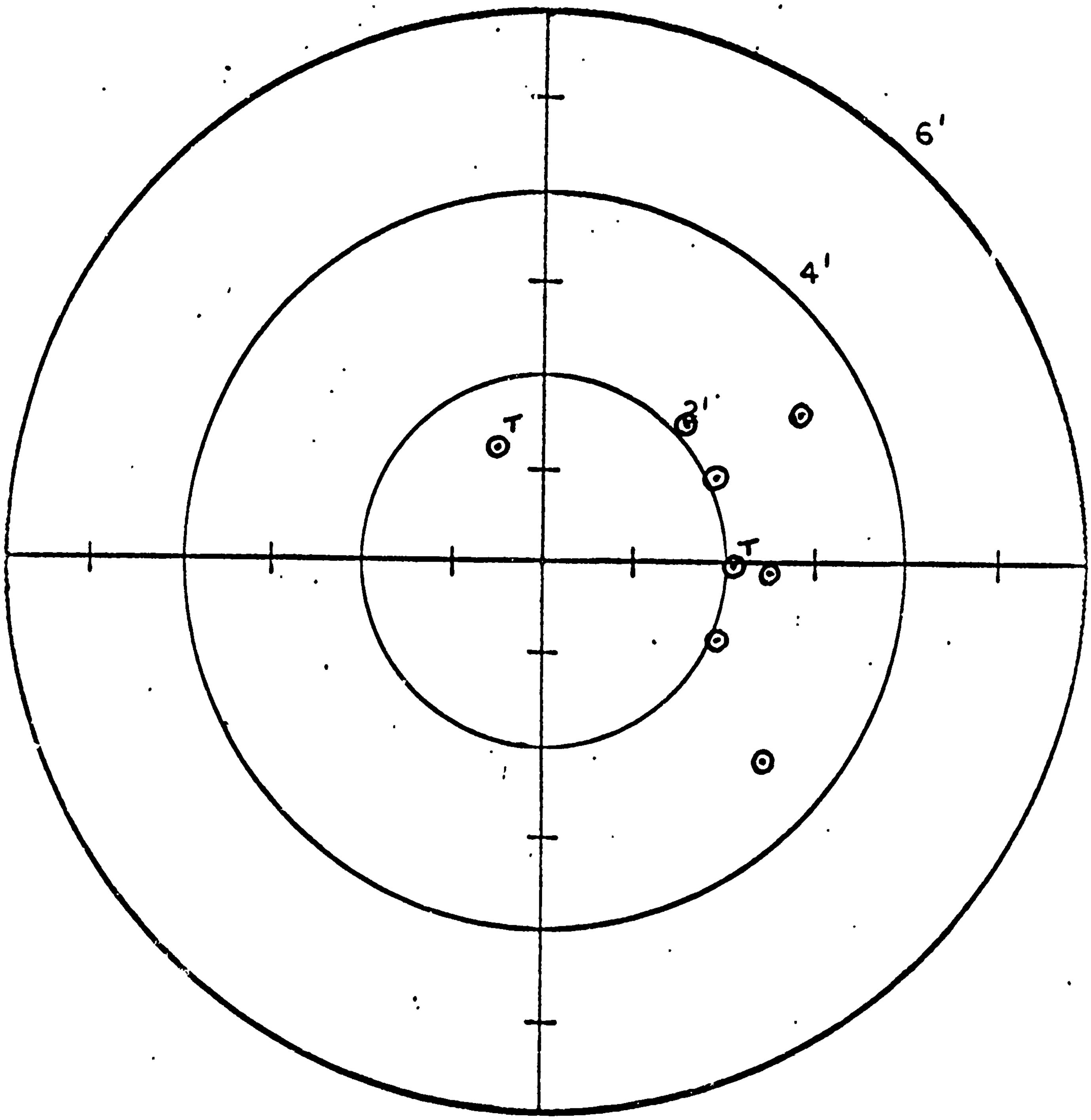
CONFIDENTIAL

Hardstand Firings

Front Barrel Brace Installed

8 April 1971

CONFIDENTIAL



T - tumbled

CONFIDENTIAL

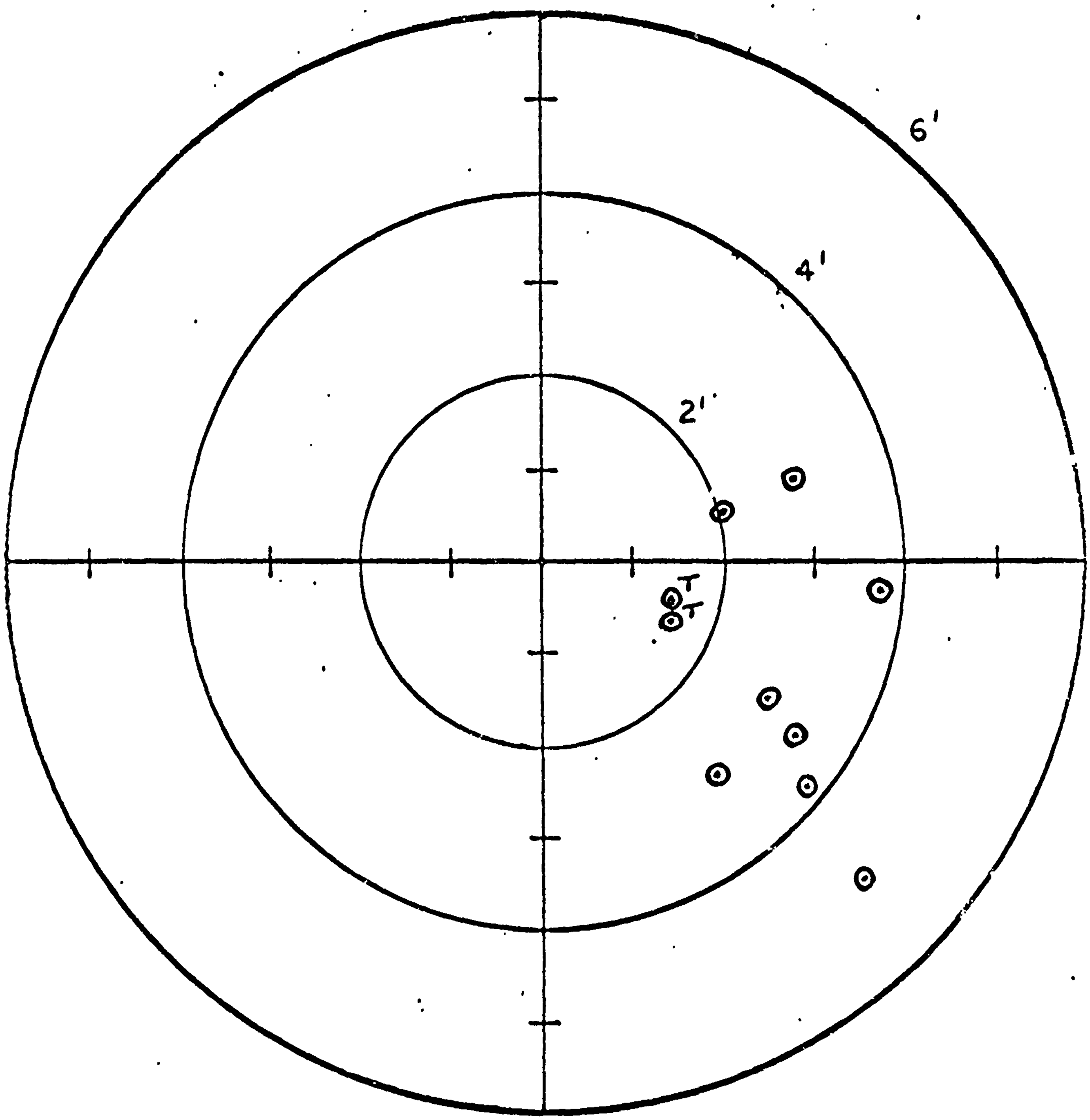
CONFIDENTIAL

Hardstand Firings

Front Barrel Brace Removed

8 April 1971

CONFIDENTIAL



CONFIDENTIAL

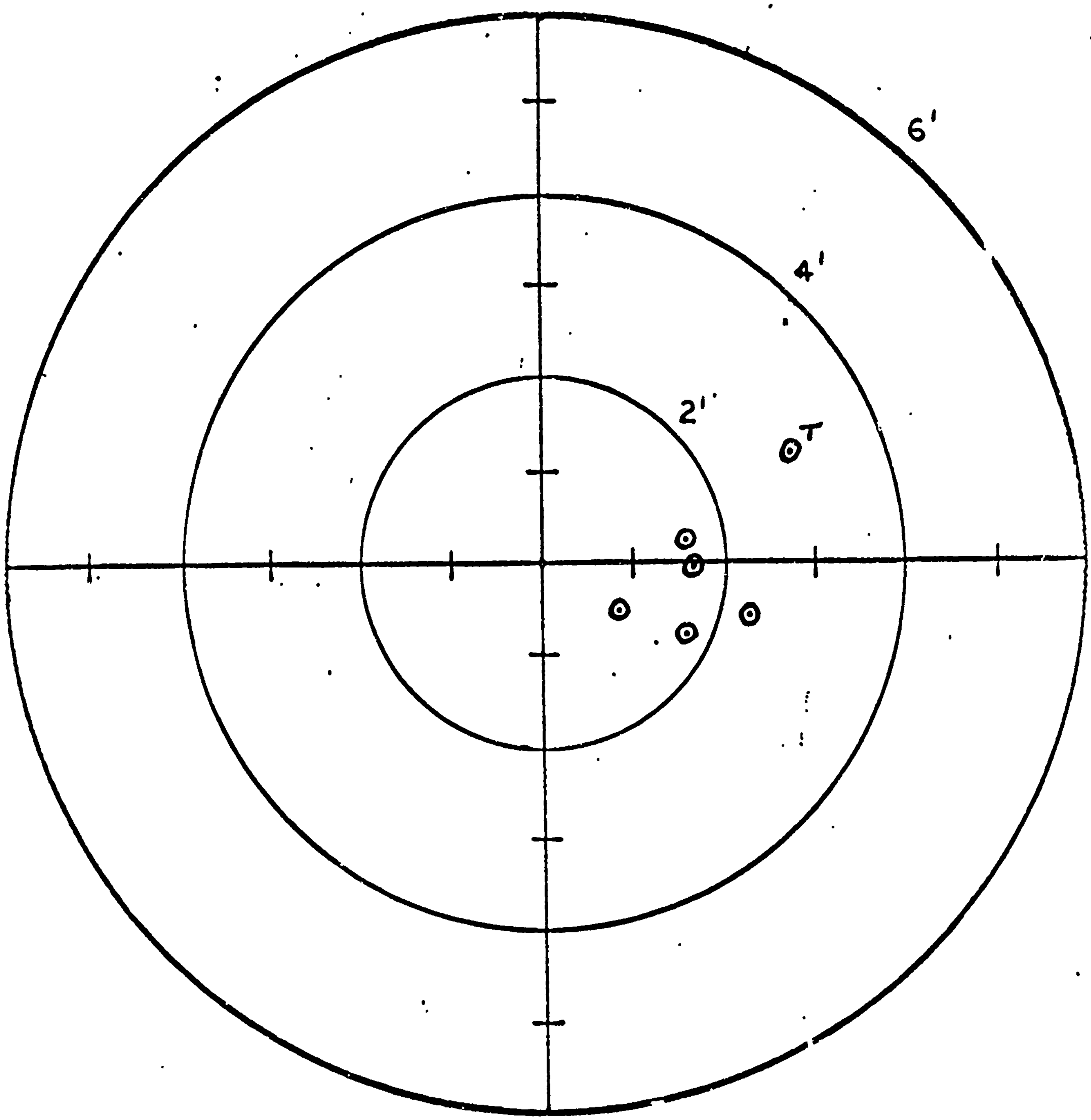
CONFIDENTIAL

Hardstand Firings

CONFIDENTIAL

New Bushing/Front Brace Re-installed

8 April 1971



T - tumbled

CONFIDENTIAL

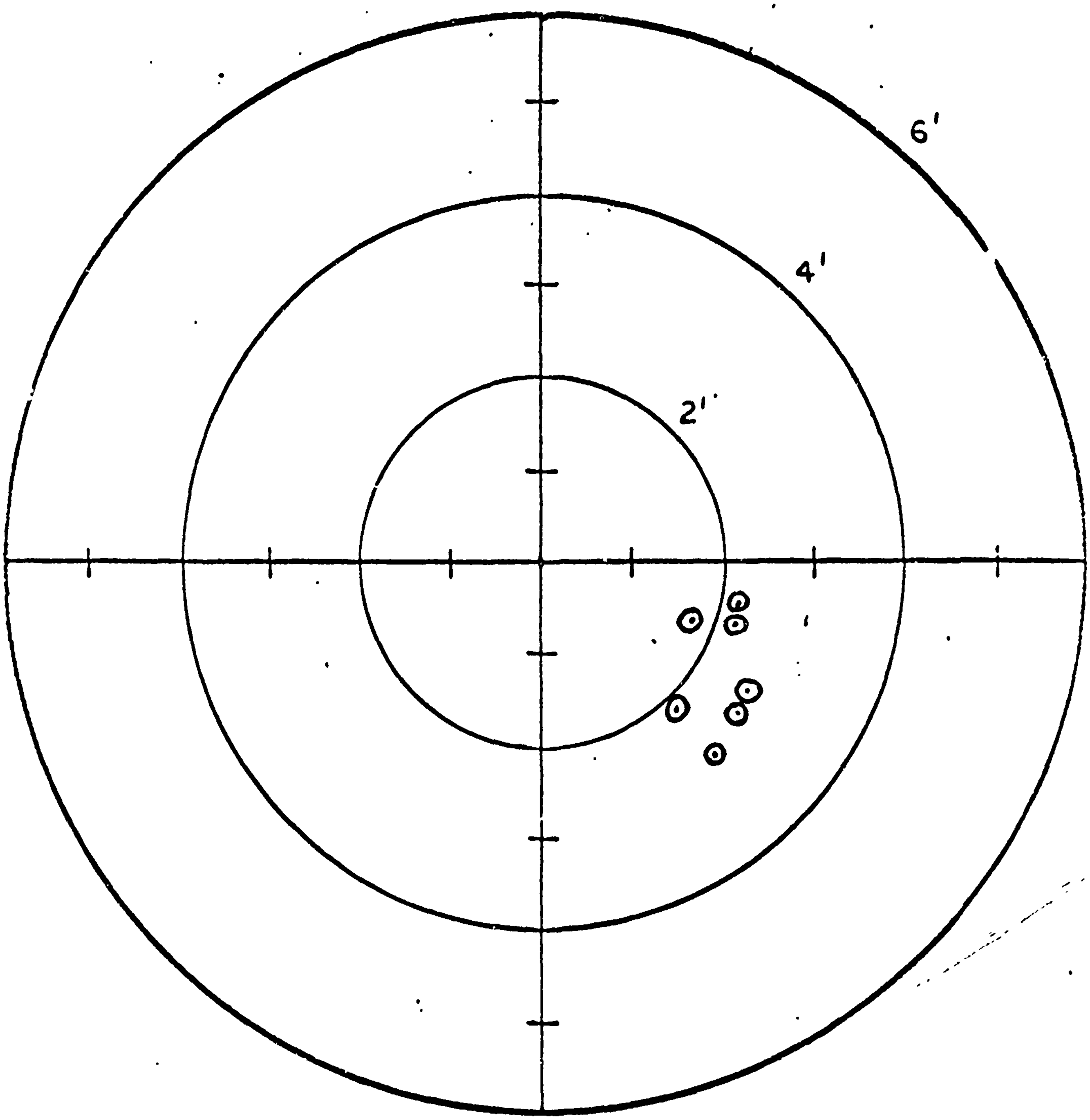
CONFIDENTIAL

Hardstand Firings

New Bushing/No Front Brace

8 April 1971

CONFIDENTIAL



CONFIDENTIAL

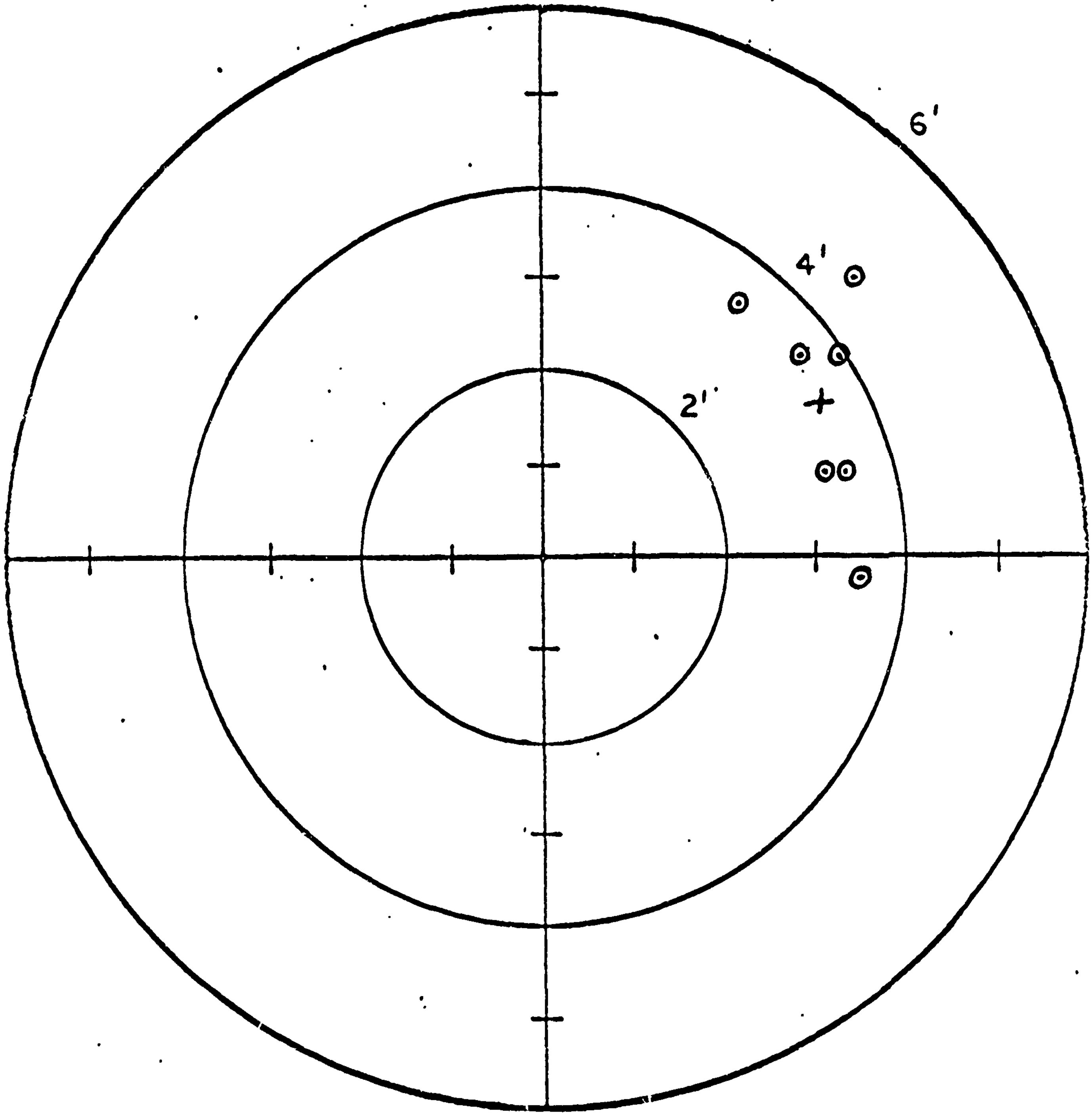
CONFIDENTIAL

Test Number 242

Boresighting and Calibration

12 April 1971

CONFIDENTIAL



+ - Centroid

CONFIDENTIAL

CONFIDENTIAL

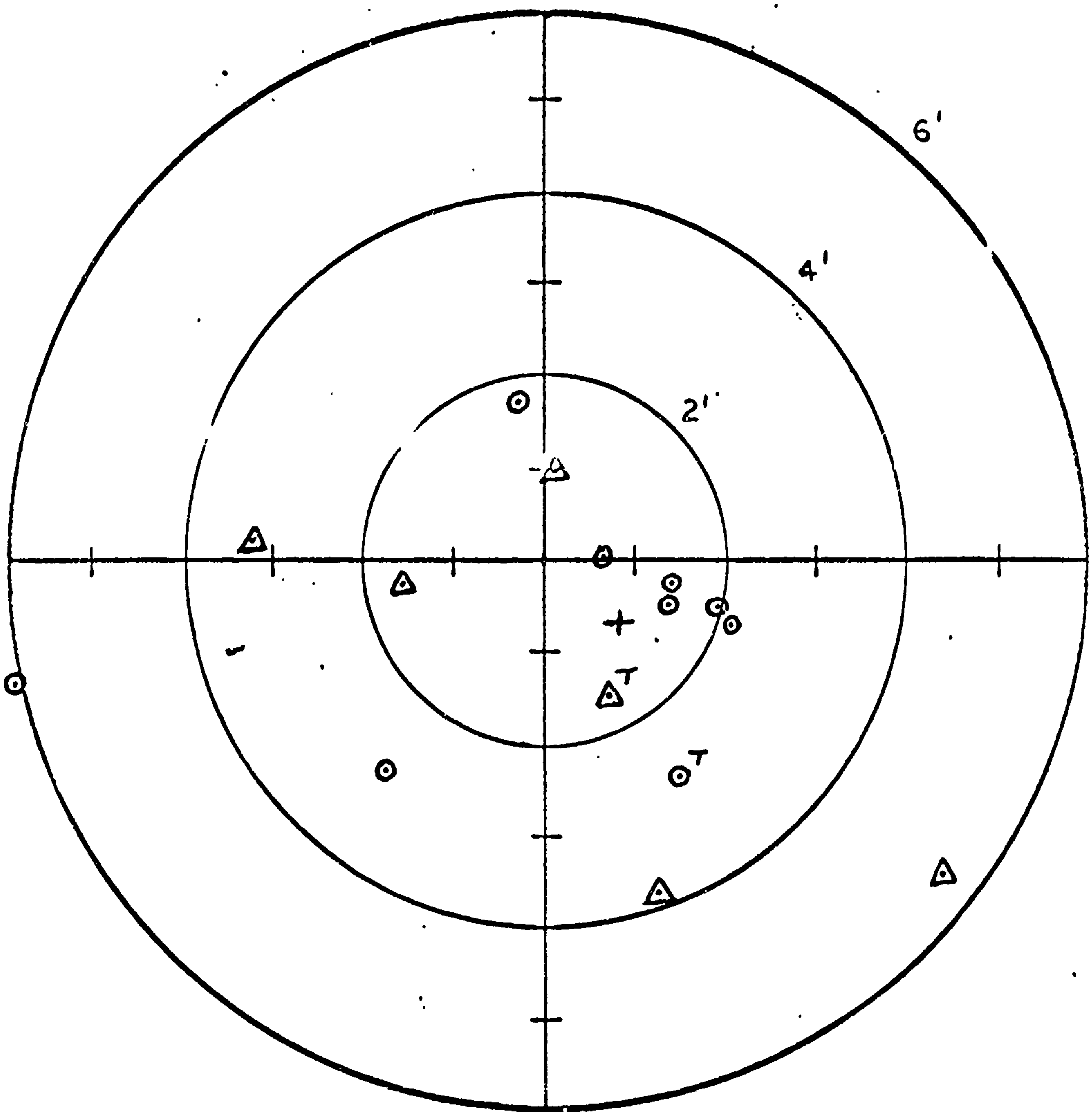
Test Number 242

Boresighting and Calibration

14 April 1971

△ Burst firing

CONFIDENTIAL



+ - Centroid
T - Tumbled

CONFIDENTIAL

CONFIDENTIAL

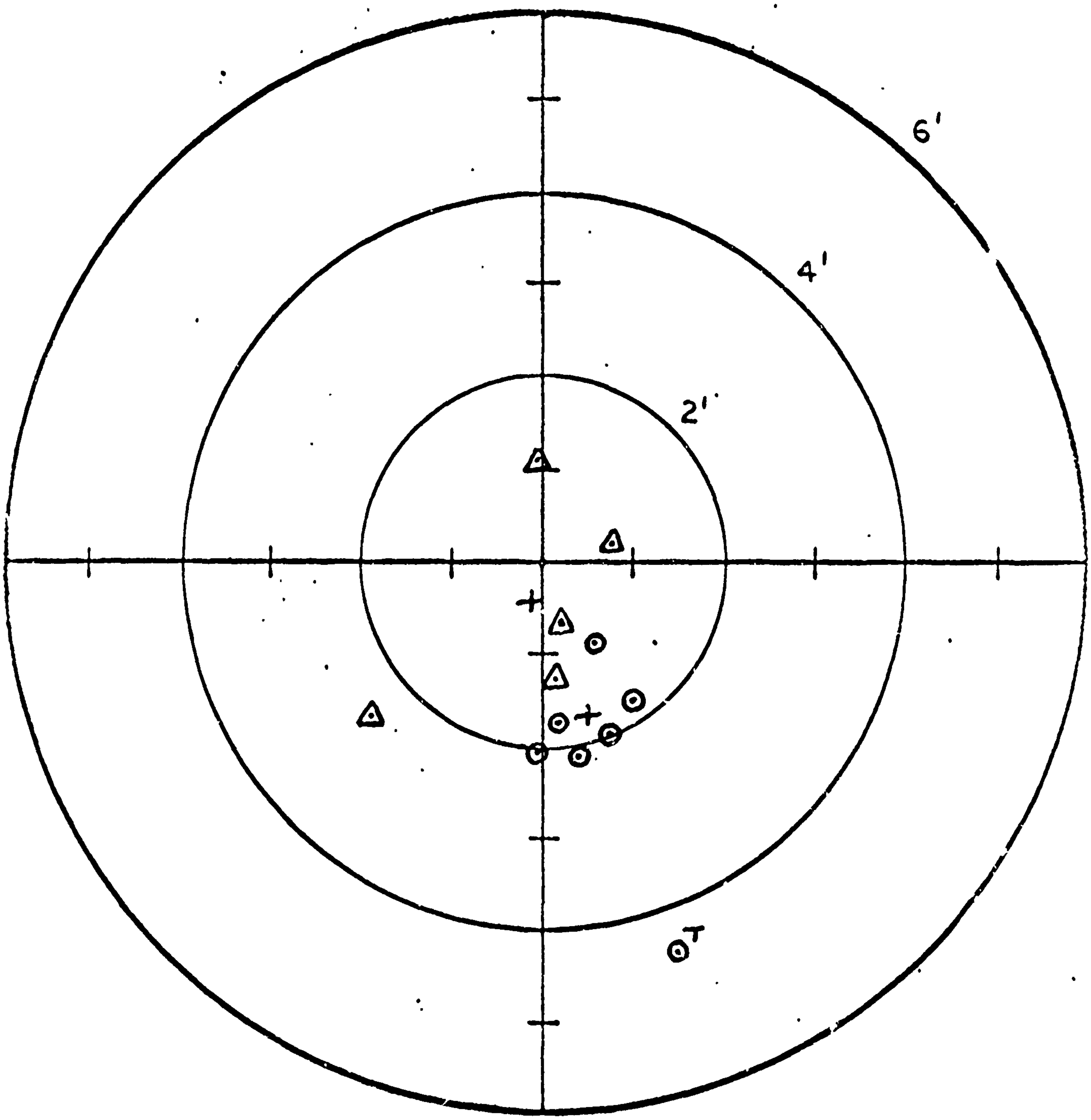
Test Number 242

CONFIDENTIAL

Boresighting and Calibration

15 April 1971

⊙ Rounds 1 thru 7
△ Rounds 10 thru 14



T - tumbled

CONFIDENTIAL

CONFIDENTIAL

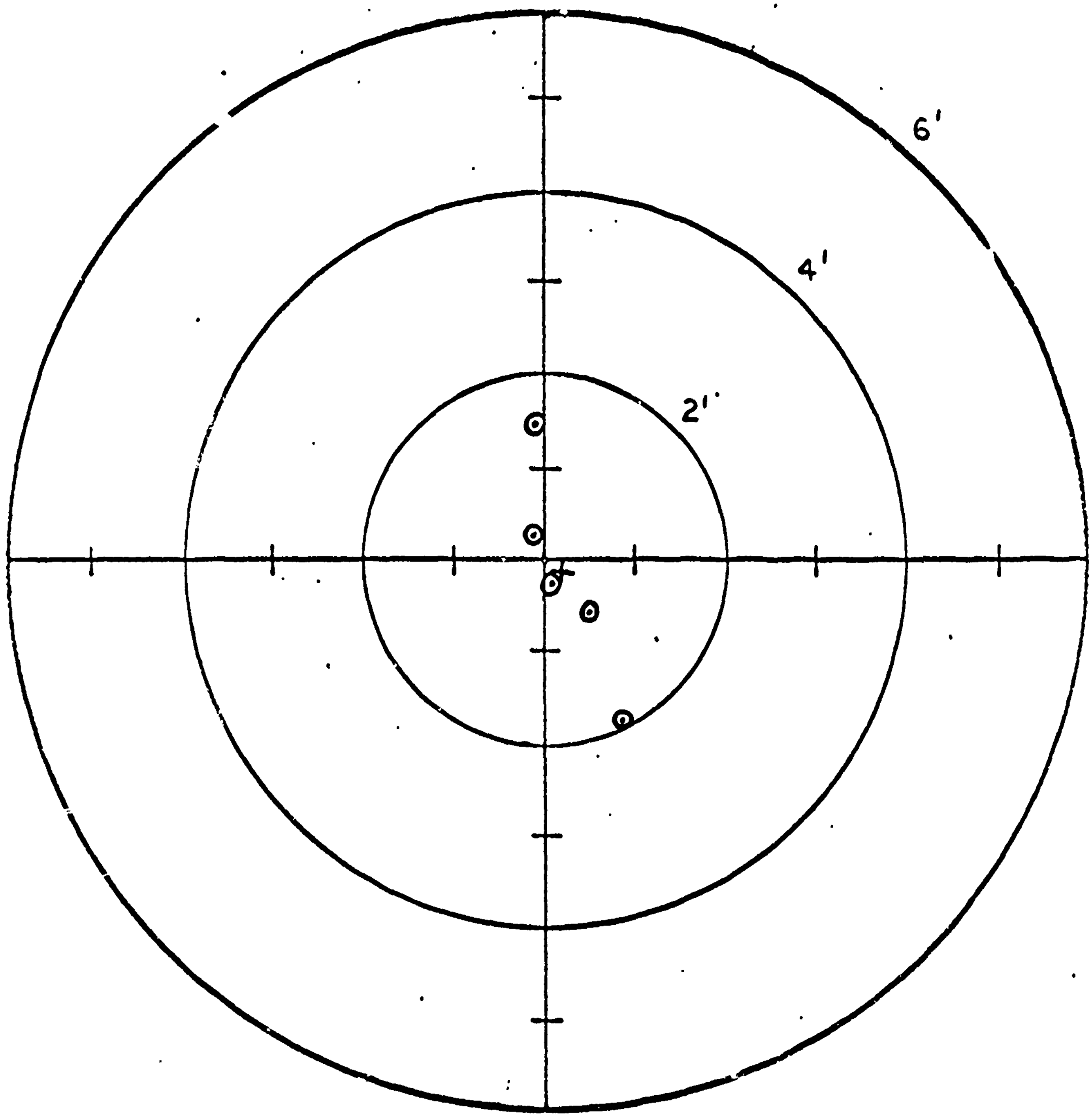
Test Number 242

Boresighting and Calibration

15 April 1971

Rounds 15 thru 19

CONFIDENTIAL



+ Centroid

CONFIDENTIAL

CONFIDENTIAL

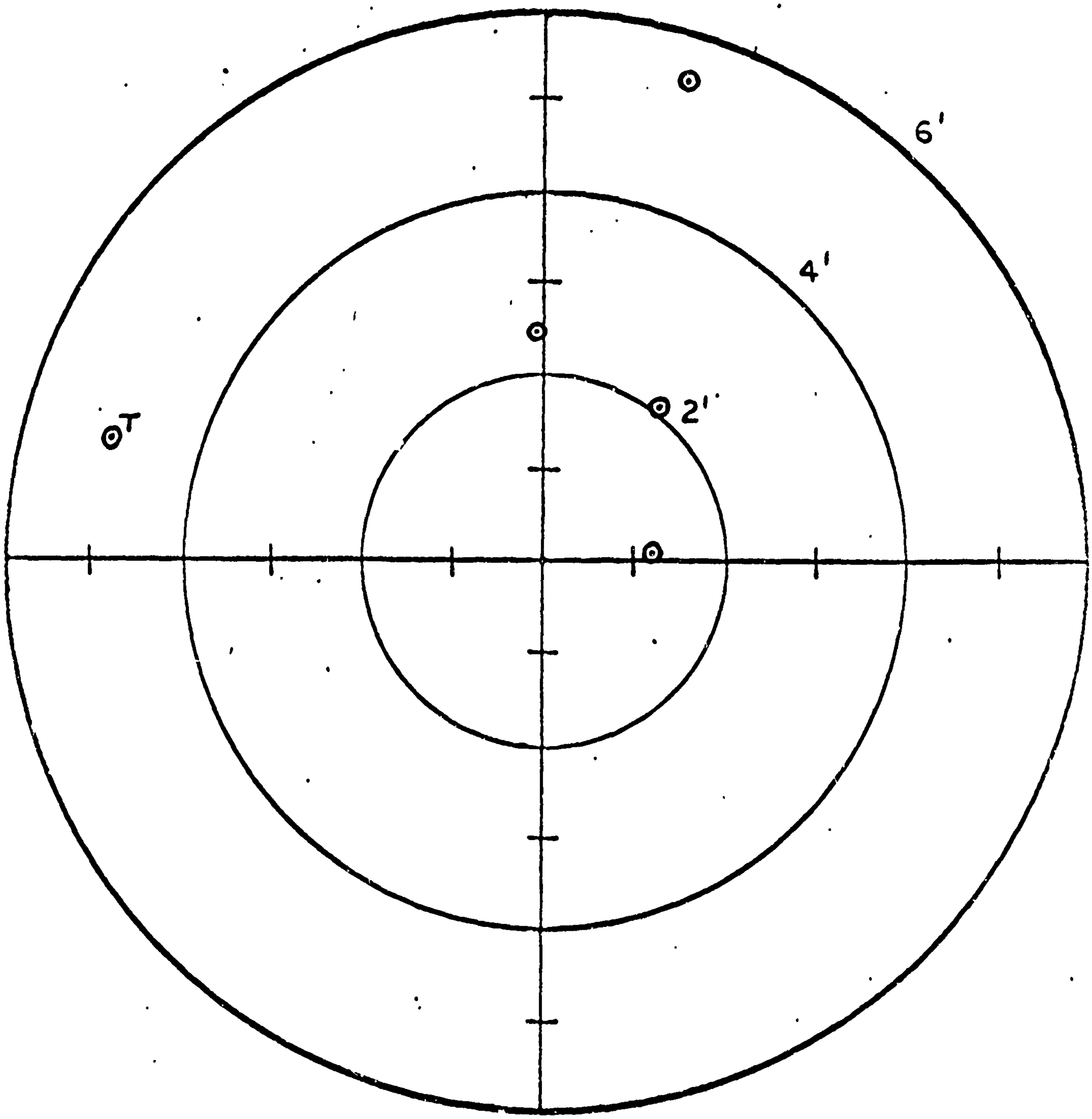
Test Number 242

CONFIDENTIAL

Boresighting and Calibration

15 April 1971

Rounds 20 thru 24
(Burst)



T - tumbled

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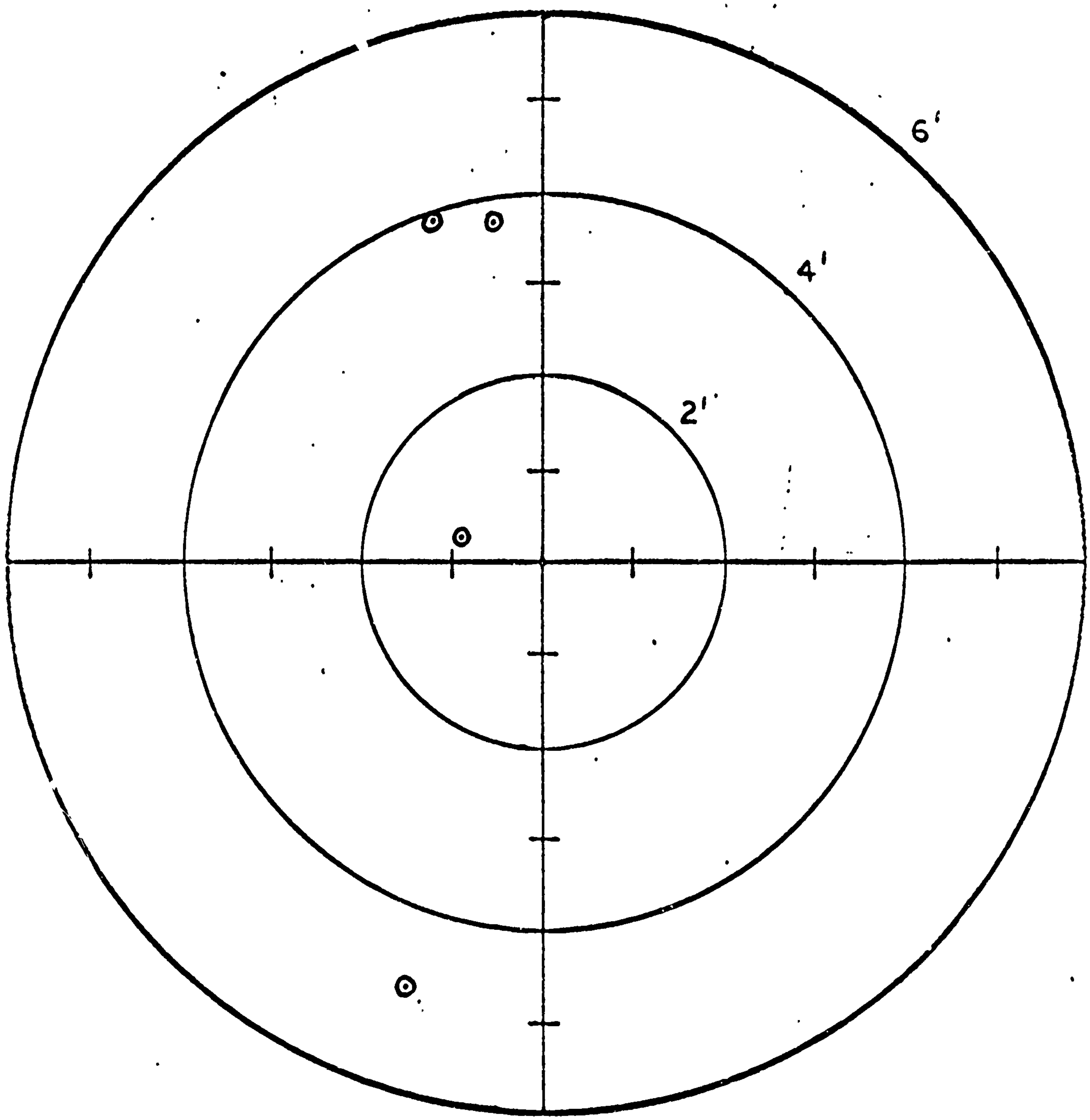
CONFIDENTIAL

Test Number 243

Flight Test

23 April 1971

CONFIDENTIAL



CONFIDENTIAL

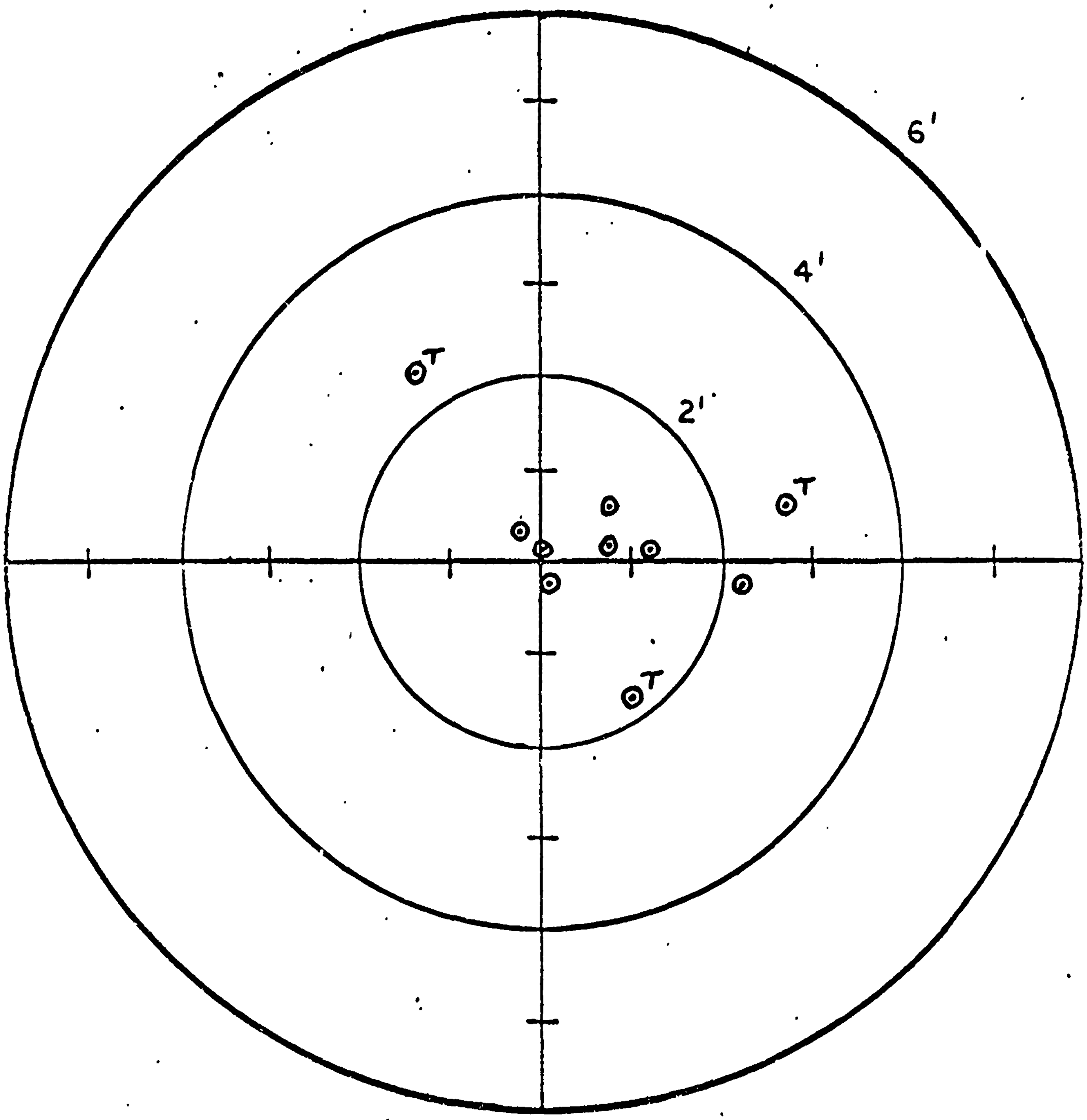
CONFIDENTIAL

Test Number 243

Flight Test

20 May 1971

CONFIDENTIAL



T - tumbled

CONFIDENTIAL

CONFIDENTIAL

APPENDIX D

DEFINITIONS, FORMULAE AND DERIVATIONS

1.0 INTRODUCTION

(U) The definitions, formulae and derivations used in the analyses of the Hypervelocity Gun test program are contained in this appendix.

2.0 DEFINITIONS

(U) The coordinate system in which the impact points and aimpoints are represented is in the plane of the target board with the origin at the center of the bull's-eye.

Delta x is the horizontal miss distance measured from the bull's-eye - positive right.

Delta y is the vertical miss distance measured from the bull's-eye - positive up.

The centroid ($\bar{x}$, $\bar{y}$) was derived by computing the mean delta x and the mean delta y.

Dispersion (S_x, S_y, S_r) is represented by a one-sigma deviation about the centroid.

3.0 FORMULAE (Unclassified)

CENTROID $(\bar{x}, \bar{y}) = \left(\frac{\Sigma x_i}{n}, \frac{\Sigma y_i}{n} \right)$

STANDARD DEVIATION $= S_x = \sqrt{\frac{x_i^2 - n\bar{x}}{n - 1}}$

STANDARD DEVIATION $= S_y = \sqrt{\frac{y_i^2 - n\bar{y}}{n - 1}}$

RADIAL DISPERSION $= \sqrt{S_x^2 + S_y^2}$

4.0 DERIVATIONS

4.1 Accuracy Computation for Test 243, 5 May 1970

(C) Test 243 data are used in the following example to demonstrate these calculations. For Test 243 on May 1971 the following impact points were recorded:

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(Delta x, Delta y) = (+9", +2"), (+9", +7"25), (-2"75, +3"75),

(+14"5, +1"5), (+27"25, -3"), (+32"75, +7"5),

(0, +1"), (-17", +24"5), (+0"75, -2"25), (+11"75, -18"25)

The Centroid ($\bar{x}, \bar{y}$) was found by computing a mean delta x and a mean delta y.

$$\bar{x} = \left[(+9'') + (+9'') + (-2''75) + (+14''5) + (27''25) + (+32''75) + (0) + (-17'') + (+0''75) + (+11''75)\right] /10$$

$$\bar{y} = \left[(+2'') + (7''25) + (+3''75) + (1''5) + (-3'') + (+7''5) + (+1'') + (+24''5) + (-2''25) + (-18''25)\right] /10$$

$$(\bar{x}, \bar{y}) = (+8''5, +2''4)$$

Dispersion values were derived by computing the standard deviation in x (S_x), the standard deviation in y (S_y) and the resultant (S_r).

$$S_x = \left(\left\{\left[(+9)^2 + (+9)^2 + (-2.75)^2 + (+14.5)^2 + (27.25)^2 + (32.75)^2 + (0)^2 + (-17)^2 + (.75)^2 + (+11.75)^2\right] - 10\,(+8.5)^2\right\} /9\right)^{1/2}$$

$$S_y = \left(\left\{\left[(+2)^2 + (+7.25)^2 + (+3.75)^2 + (+1.5)^2 + (-3)^2 + (+7.5)^2 + (+1)^2 + (+24.5)^2 + (-2.25)^2 + (-18.25)^2\right] - 10\,(+2.4)^2\right\} /9\right)^{1/2}$$

$$(S_x, S_y) = (14''5,\ 10''6)$$

Inches at the range of 1500 feet are converted to mils:

$S_x = 14.5/18 = .81$ mil

$S_y = 10.6/18 = .59$ mil

Radial dispersion was computed:

$S_r = \left[(.81)^2 + (.59)^2\right]^{1/2} = 1.00$ mil

4.2 Three-sigma Kill Probability

(C) The computation for the seven round three-sigma kill probability was based on the following assumptions:

system bias (SB) = .49 mil
random error (RE) = 1.00 mil

target radius (TR) = 1.25 feet
total error (TE) = $\left[(SB)^2 + (RE)^2\right]^{1/2}$
range from target = 1500 feet
a normal distribution of impacts on Test 243, 5 May 1971.

(C) The following steps describe the method used to arrive at the number of rounds required for a three sigma kill probability.

Step 1. The total error (TE) was computed to be 1.11 mils or 1.67 feet at the 1500 foot range.

Step 2. The target radius was determined in terms of system total error. (TR) = .75 (TE)

Step 3. The probability of hitting the target (PH) was derived from a normal curve of error table, "CRC Handbook of Chemistry and Physics". The percentage of area under the curve at .75 (TE) was taken as the hit probability. It was 54.68%.

Step 4. The probability of missing the target (PM) is 100% - (PH) = 45.32%.

Step 5. The three-sigma probability of missing the target is .27% (CRC Handbook of Chemistry and Physics).

Step 6. The number of rounds (N) needed to assure a three-sigma hit probability is computed from $(.4532)^N \leq .0027$. N = 7.

8.0 NITE GAZELLE/BOMBLET DISPENSER WEAPON SYSTEM (U)

ABSTRACT

(C) The NITE GAZELLE/Bomblet Dispenser Weapon System was designed to dispense 2.75 inch diameter bomblets against personnel and light materiel. The system is capable of six bombing runs, dispensing from forty-two to fifty-two bomblets per run depending on bomblet type.

(C) The system was tested against grid targets on Range 3 of Nellis AFB, Nevada from 9 March 1970 through 11 June 1970. Thirteen flight tests were conducted at airspeeds of 30 to 60 knots and altitudes of 600 to 3,000 feet. Test results show the average measured impact pattern covered an area 40 feet wide and 170 feet long with forty-two bomblets.

NITE GAZELLE/Bomblet Dispenser Weapon System in Flight

Figure 1

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

(C) This program report evaluates the performance of the Bomblet Dispenser Weapon System on the remotely piloted NITE GAZELLE helicopter. This weapon system is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems.

(C) The ARPA/Advanced Sensors NITE GAZELLE remotely piloted helicopter, with appropriate day/night sensors and target kill weapons, was conceived as an interdiction system to counter enemy infiltration along the waterways and roads of Southeast Asia. The sensors were selected to give the helicopter a real time navigation, target acquisition and optical fire control capability under both day and low light level conditions of night.

(C) The weapon package of the NITE GAZELLE/Bomblet Dispenser Weapon System was selected to deliver any of a wide variety of anti-personnel and anti-materiel bomblets. The helicopter, a Navy-Gyrodyne QH-50D ASW-20, is remotely piloted auto-flight controlled, with the ground command and control elements of the system located in a trailer van.

(C) The ARPA NITE GAZELLE/Bomblet Dispenser Weapon System can be remotely piloted to any point within a 50 nautical mile radius and provides 30 minutes on station at its tactical destination. The helicopter is navigated through the use of Distance and Azimuth Measuring Equipment (DAME). Wide angle TV video is transmitted to the control station for real time visual search for targets. The gun controller, using the TV zoom lens, can zoom in on acquired targets or points requiring closer scrutiny. The TV video with projected reticle gives the gun controller an accurate aiming device. There are a total of twelve bomblet dispenser tubes, six on each side of the helicopter, which are fired in pairs. Each tube holds from 19 to 26 bomblets and provides a total payload of about 300 bomblets.

(C) The flight test program covered by this report was conducted at Nellis Air Force Base, Nevada, from 9 March 1970 through 11 June 1970. Bomblets were dispensed against stationary CBU (Cluster Bomb Unit) grid targets. The distribution of bomblet impacts were plotted, and several bomblet types were evaluated by gathering dud rate data. A total of thirteen flight tests were conducted in which approximately 1,700 bomblets were dispensed.

2.0 RESULTS

2.1 Summary of Results

(U) The Bomblet Dispenser test program ran from 9 March 1970 through 11 June 1970. Thirteen flights containing forty-four bomblet drops were successfully flown. Bomblet impacts were measured and duds counted.

(C) The impact patterns were graphed and are displayed in Appendix C. They ranged in size from 80' x 30' to 280' x 50' with the average being 170' x 40'. Bomblet drops were conducted at airspeeds of 30 to 60 knots and altitudes ranging from 600 to 3,000 feet.

(C) BLU-3, BLU-24 and BLU-26 bomblets were evaluated to assess their compatibility with the NITE GAZELLE/Bomblet Dispenser Weapon System. BLU-3 and BLU-24 bomblets were found to be more compatible with the NITE GAZELLE delivery system than were the BLU-26 bomblets. See Table 1 below.

TABLE 1 (Title Unclassified
Table Confidential)

DUD RATES

Bomblet Type	Number Tested	Number of Duds	Dud Rate
BLU-3 (Note 1)	152	77	51%
BLU-3 (Note 2)	1026	94	9%
BLU-24	189	27	14%
BLU-26	250	(Note 3)	100% (approx.)

Note 1 - packed prior to shipping
Note 2 - freshly packed
Note 3 - specific number is not available

2.2 Discussion of Test Results

(C) Thirteen test flights were conducted. Only one flight test was aborted; a malfunction in the DAME system was caused by radio interference. About seventeen hundred bomblets were dropped in forty-four Bomblet Dispenser firings. Graphed impact patterns with respect to aimpoint were obtained on 30 of these firings.

(C) Ripple firing was tested and found to be hazardous in maintaining control of the helicopter. Three pair of tubes were ripple fired (fired in rapid succession) in Flight No. 6. The helicopter pitched up 15° and pitch control was temporarily lost.

(C) BLU-3, BLU-24 and BLU-26 bomblets were evaluated at various altitudes and airspeeds. BLU-26 dispensed bomblets had a dud rate of almost 100 percent. BLU-3 and BLU-24 dud rates were much lower. See Table 1. It was noted that freshly packed BLU-3 bomblets had a much lower dud rate than those which were shipped to Nellis AFB, already packed.

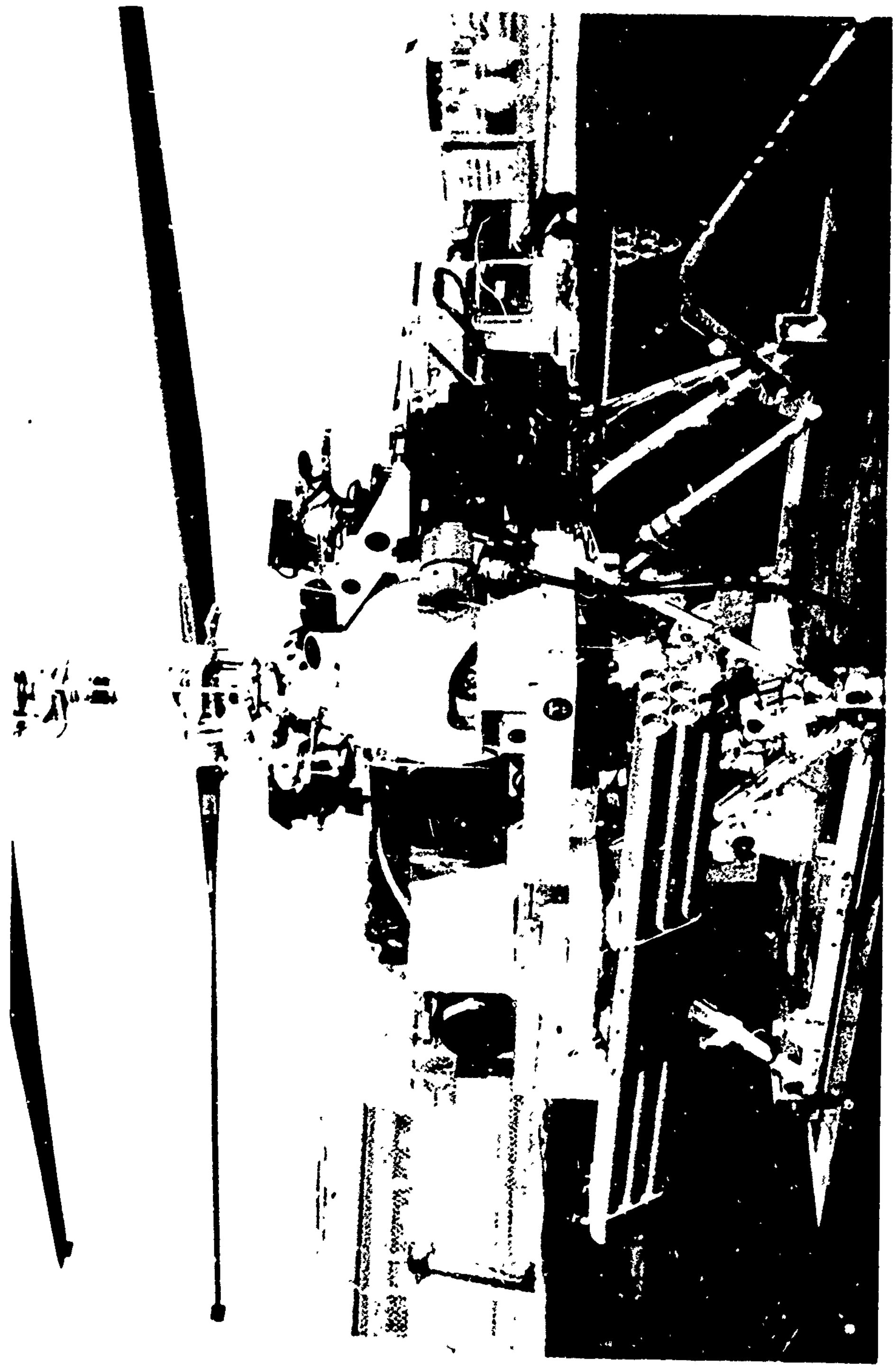
(C) Review of the Tracking Camera motion picture film documenting the mid-air collision test, Test No. 20, of 20 March 1970 revealed no collisions. However, film coverage of the six bomblet drops of Test No. 20 only partially covered the full field of descending bomblets for segments of their descent.

3.0 SYSTEM DESCRIPTION

(C) The Bomblet Dispenser Weapon System consists of two XM-18 Bomblet Dispensers, one attached to each side of the helicopter. The dispensers are fired simultaneously, one tube on each side of the helicopter. The dispensers eject bomblets from the rear of the helicopter at an ejection velocity of 42 feet per second. There may be as many as 26 bomblets per tube, so the maximum payload for the weapon system is 312 bomblets. All 2.75 inch diameter munitions may be used with these dispensers.

(U) The primary sensor for optical fire control of the weapon system is the day television system, mounted on the "Big U" tracking mount.

(U) A more detailed description of the system is contained in Appendix A.



NITE GAZELLE/Bomblet Dispenser
Weapon System in Flight
Figure 1

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The main objectives of this test program were:

1) To evaluate the compatibility of the weapon system with the day/night on board sensors, and the use of these sensors as fire control devices.

2) To evaluate the capability of the system to recognize and acquire a specified target prior to a firing run.

3) To evaluate the hit distribution of the bomblet dispenser.

4) To test for mid-air bomblet collisions.

5) To evaluate the compatibility of various types of bomblets with the NITE GAZELLE/Bomblet Dispenser Weapon System.

4.2 Test Plan

(U) Bomblet drop tests were conducted over two grid areas - the North CBU Grid and the South CBU Grid. The North CBU Grid is laid out in 100 foot squares and is 1,200 feet by 6,000 feet. The South CBU Grid is laid out in 200 foot squares (except for a small area in the center which is laid out in 100 foot squares) and is 1,000 feet by 3,000 feet. Designated targets were placed within these grids. The North CBU Grid lines run at 347.5 degrees referenced to true north; the South CBU Grid lines run at 335 degrees.

(U) Test runs were conducted at altitudes from 600 to 3,000 feet and airspeeds from 30 to 60 knots approaching the grid targets from the south. The designated targets were used for sighting. Impact points were measured within the grid system and the impact patterns were graphed with respect to aimpoint.

(C) BLU-3, BLU-24 and BLU-26 bomblets were tested for compatibility with the NITE GAZELLE/Bomblet Dispenser Weapon System. After each bomblet drop, the dispensed bomblets were checked to determine if the firing mechanism had been triggered. Dud rates were collected for each type of bomblet.

(C) In order to test for mid-air bomblet collisions, a special smoke bomblet was used which was designed to flag mid-air collisions with smoke. High speed motion picutres (200 fps) taken from a tracking camera documented bomblet dispensings and their descent.

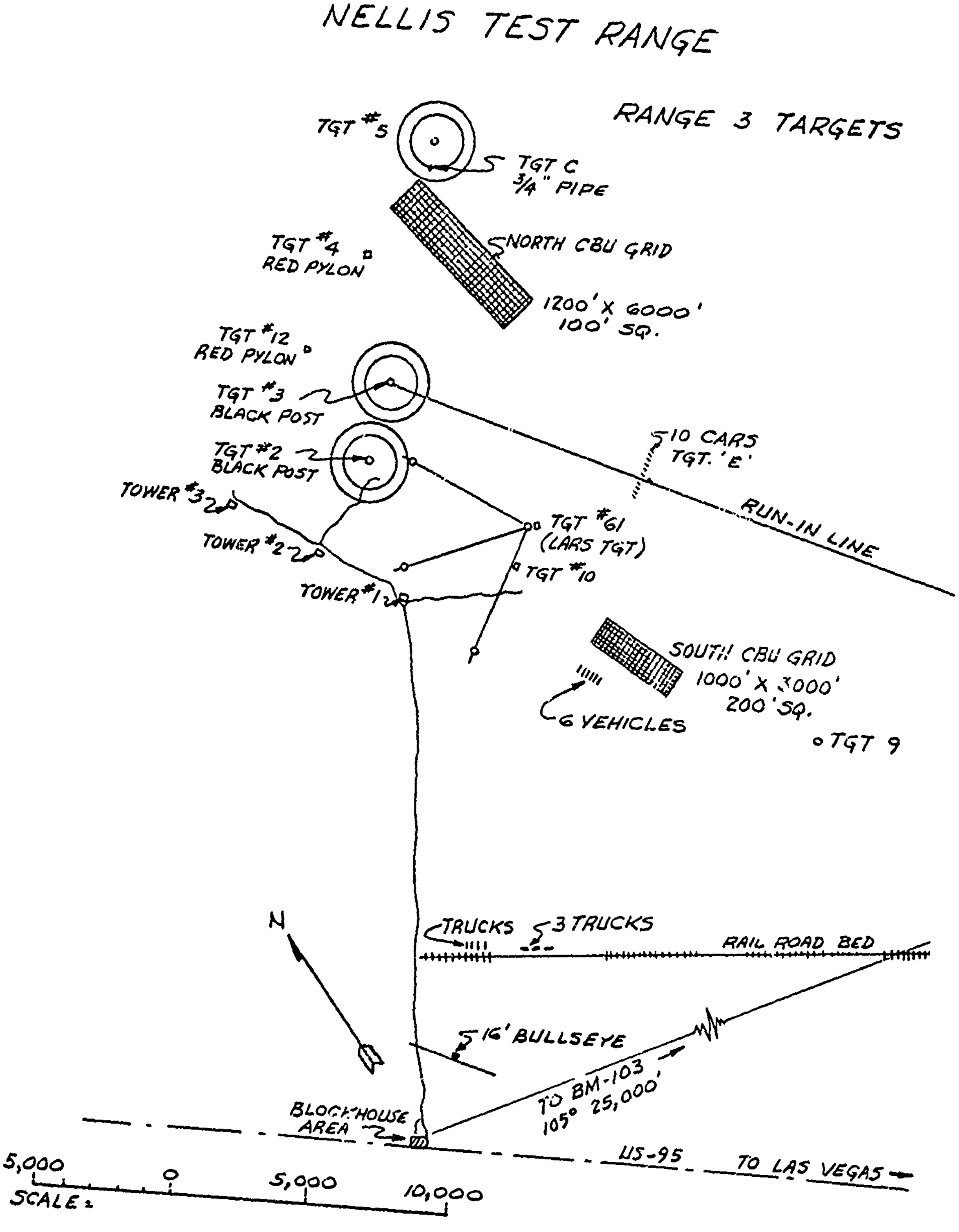

NELLIS TEST RANGE
RANGE 3 TARGETS
TGT #5
TGT C
3/4" PIPE
TGT #4
RED PYLON
NORTH CBU GRID
1200' X 6000'
100' SQ.
TGT #12
RED PYLON
TGT #3
BLACK POST
10 CARS
TGT. 'E'
TGT #2
BLACK POST
TOWER #3
RUN-IN LINE
TGT #61
(LARS TGT)
TOWER #2
TGT #10
TOWER #1
SOUTH CBU GRID
1000' X 3000'
200' SQ.
6 VEHICLES
TGT 9
N
TRUCKS
3 TRUCKS
RAIL ROAD BED
16' BULLSEYE
TO BM-103
105° 25,000'
BLOCKHOUSE
AREA
US-95
TO LAS VEGAS
5,000
0
5,000
10,000
SCALE:

Figure 3

5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the following areas:

Bomblet Dispensers
Bomblets
Helicopter
Data Link
Ground Station
Television
Tracking Mount

5.1 Bomblet Dispensers

5.1.1 Conclusions

(C) The XM-18 Bomblet Dispensers proved to be an effective and reliable weapon system during this test program.

5.1.2 Recommendations

(U) None

5.2 Bomblets

5.2.1 Conclusions

(C) Freshly packed bomblets had a lower dud rate than those packed before shipping.

(C) BLU-3 and BLU-24 bomblets proved to be compatible with the NITE GAZELLE delivery system; BLU-26 bomblets did not, however, this is based on very limited testing.

5.2.2 Recommendations

(U) Further testing is needed to verify these results.

5.3 Helicopter

5.3.1 Conclusions

(C) The helicopter proved to be a reliable vehicle during the test program.

5.3.2 Recommendations

(U) None

5.4 Data Link

5.4.1 Conclusions

(C) The data link performance for command data to the helicopter and response data from the helicopter was satisfactory.

5.4.2 Recommendations

(U) None

5.5 Ground Station

5.5.1 Conclusions

(C) The ground station proved to be effective for all aspects of the test program.

5.5.2 Recommendations

(U) None

5.6 Television

5.6.1 Conclusions

(C) The high resolution television system provided satisfactory information for target location and identification.

5.6.2 Recommendations

(C) A table of altitudes and ground speeds versus mount depression angle would enhance the optical fire control potential of the television system. Such a table should be compiled.

5.7 Tracking Mount

5.7.1 Conclusions

(C) Bomblet impacts are not observed on the television system because the impacts occur farther behind the helicopter than the television field of view at the maximum mount depression angle.

5.7.2 Recommendations

(C) If this feature is desirable, a mount modification should be investigated to extend the depression angle beyond -100 degrees.

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GLOSSARY

CBU	Cluster Bomb Unit
DAME	Distance and Azimuth Measuring Equipment
UHF	Ultra High Frequency

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(C) The system under test consisted of two XM-18 bomblet dispensers, one attached to each side of the helicopter. Several 2.75 inch diameter bomblet types were dispensed from a remotely piloted helicopter.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE remotely piloted helicopter is a modified counter-rotating, double-bladed helicopter, which was originally developed by the U.S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding an 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius of the NITE GAZELLE/Bomblet Dispenser Weapon System is 50 nautical miles with 30 minutes on station.

2.2 The Surveillance Tracking and Weapons Mount

(U) The "Big U" is a rate commanded, inverted U-shaped, gyro-stabilized weapon/sensors mount. The sensors are mounted on a platform suspended between the two arms of the "Big U". The mount insulates the sensors from extraneous vibrations.

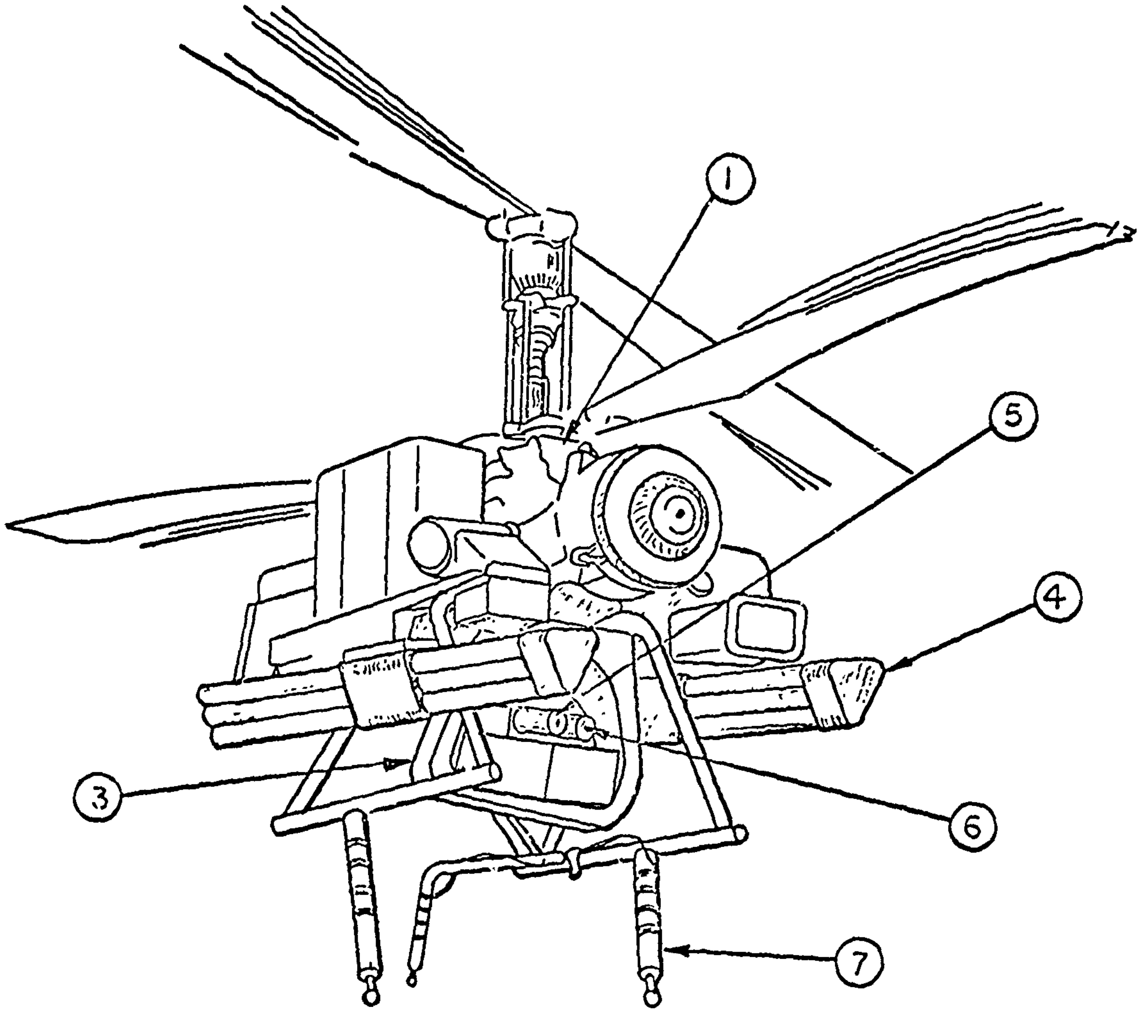
(U) The platform is remotely controlled in pan and tilt for accurate target tracking. The "Big U" can be moved through a traverse angle of ±25° at a maximum pan rate of 2° per second. The platform can be depressed from the horizontal to -100° at a maximum tilt rate of 3° per second.

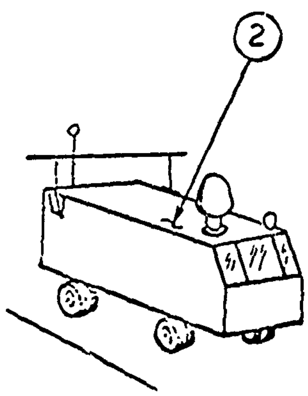
(U) The mount is centrally located under the drive shaft to provide maximum stability during in-flight operations.

2.3 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and a fire control position for target acquisition and optical fire control capability.

(U) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data are sent to the ground via an S-band link and TV imagery is transmitted to the ground via an L-band link.





NITE GAZELLE BOMBLET DISPENSER

1. HELICOPTER DRONE QH-50D (UNFAIRED)
2. NITE GAZELLE CONTROL VAN
3. SURVEILLANCE TRACKING AND WEAPON MOUNT "BIG U",
4. DISPENSER TUBES
5. 16MM MOTION PICTURE CAMERA
6. DAY TELEVISION
7. ANTENNA

Figure A-1

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communication relay system, permits operations beyond ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

(U) The fire controller monitors the surveillance tracking and controls the mount while viewing TV video. He controls the TV camera zoom lens, the 16 mm film camera, and transmits the firing signals.

2.4 NITE GAZELLE/Bomblet Dispenser

(C) The NITE GAZELLE/Bomblet Dispenser Weapon System uses two XM-18 Bomblet Dispensers - one attached to each side of the helicopter. The XM-18 Bomblet Dispenser is a 6-tube, cartridge discharge type dispenser. The weapon is 81 inches in length and weighs about 250 pounds with bomblets. All 2.75 inch diameter munitions may be used with this dispenser. Total weapon system weight is 550 pounds.

(C) The NITE GAZELLE/Bomblet Dispensers are fired simultaneously - one tube from each side of the helicopter. The dispenser ejects bomblets from the rear of the helicopter at an ejection velocity of approximately 42 feet per second. There may be as many as 26 bomblets per tube, so the maximum payload for the weapon system is about 300 bomblets.

(C) BLU-3, BLU-24 and BLU-26 bomblets were used in the test program. BLU-3 is an anti-materiel bomblet that detonates on impact. BLU-24, weighing 1.6 pounds, is a small anti-personnel bomblet designed to penetrate foliage and detonate after spin is reduced below 2,000 rpm. BLU-26, weighing .9 pounds, is a spin-armed, self-dispersing fragmentation bomblet which detonates on impact and is used against light materiel and personnel.

2.5 Day Television System

(U) The Day Television System is used as the primary sensor on the NITE GAZELLE/Bomblet Dispenser Weapon System. The camera unit is manufactured by COHU Electronics Corporation. This cylindrical unit is 4 inches in diameter, 19 inches long and weighs 27 pounds. Resolution is 945 lines at one footcandle illumination on the face plate.

(U) The camera lens is a 30 mm to 300 mm zoom with a 2X extender changing focal length and zoom to 60 mm to 600 mm, f4 to f48, covering a field of view of 23 degrees down to 2.3 degrees at full zoom. The zoom and f-stop are remotely controlled from the fire controller's station on the ground. The lens system includes a fixed reticle which is remotely illuminated and extinguished.

(U) The TV transmission requires a bandwidth of 20 MHz, and a power requirement of 45 watts.

2.6 16 mm Motion Picture Camera

(U) The 16 mm Motion Picture Camera is co-mounted beside the TV camera. A filmed record of the mission is obtained for post-flight evaluation.

(U) The camera is manufactured by Photosonics and operates at a frame rate of 24 to 200 frames per second. It is fitted with a 25 mm to 250 mm zoon lens with a normal aperture of f2.8-22. The focal length is remotely controlled in flight to maintain proper magnification and field of view to document the mission. The on board exposure control unit is automatic.

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR BOMBLET DISPENSER

Date	Test No.	Plan	Comments
3 9 70	14	Impact and Dud Rate Scoring	One firing run. One pair of tubes dispensed and scored. Flight terminated after first run due to failure of DAME.
3/11/70	14A	Impact and Dud Rate Scoring	Four firing runs. One pair of tubes dispensed and scored on each run.
3/13/70	15	Impact and Dud Rate Scoring	Six firing runs. One pair of tubes dispensed and scored on each run.
3/17/70	16	Impact and Dud Rate Scoring	Six firing runs. One pair of tubes dispensed and scored on each run.
3/18/70	15A	Impact and Dud Rate Scoring	Six firing runs. One pair of tubes dispensed and scored on each run.
3/18/70	18A	Impact and Dud Rate Scoring	One ripple firing. Three pairs of dispenser tubes ripple fired and scored. Ripple firing caused temporary loss of helicopter control.
3/19/70	21	Impact and Dud Rate Scoring	Three firing runs. One pair of tubes dispensed on each run. No scoring data available.

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Table B-1 Continued

Date	Test No.	Plan	Comments
3/20/70	20	Impact, Dud Rate and Mid-air Collision Scoring	Six firing runs. One pair of tubes dispensed and scored on each run.
6/9/70	-	Check Flight	All systems functioned properly.
6/10/70	122	Dud Rate Scoring	Five firing runs. One pair of tubes dispensed and scored on each run.
6/11/70	120	Dud Rate Scoring	Three firing runs. Only one side fired due to dispenser loading error.
6/11/70	121	Dud Rate Scoring	Three firing runs. One pair of tubes dispensed and scored on each run.

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APPENDIX C

FLIGHT TEST DATA FOR BOMBLET DISPENSER

(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

BLU-3 BOMBLET TEST
Flight No. 1 Test No. 14
9 March 1970

(C) This test was conducted over the North CBU grid for the purpose of collecting hit distribution and dud rate data. Bomblets from one pair of tubes were dispensed at an altitude of 600 feet and an airspeed of 30 knots. The size of the impact pattern was 140' x 35'. Miss distance is not available for this drop. A 50% dud rate resulted from the low altitude at which the bomblets were dispensed. The flight was terminated after the first run due to failure of the DAME system. Flight duration was forty-two minutes.

Weather Conditions

Barometric Pressure: 26.43" Hg
Temperature: 68° F
Wind: 10 knots from 120° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	Not Available	92°	-4°

BLU-3 BOMBLET TEST
Flight No. 2 Test No. 14A
11 March 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution and dud rate data. One pair of dispenser tubes was fired on each of four runs at an altitude of 600 feet and airspeeds of 30 and 60 knots. Impact pattern dimensions were 50' x 145', 40' x 80', 50' x 90' and 50' x 125'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter altitude and airspeed were not used. Bomblets impacted between 100 and 200 feet beyond the target on each of the four runs. The dud rate was 51 percent. Flight duration was twenty-five minutes.

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Weather Conditions

Barometric Pressure: 26.63" Hg
Temperature: 50° F
Wind: 5 knots from 330° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	25°	93°	+15°
2	60	600	335°	90°	-14°
3	60	600	340°	95°	-15°
4	60	600	335°	90°	- 8°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point X (feet)	Median Impact Point Y (feet)	Dispersion S_x (feet)	Dispersion S_y (feet)	Reference Target (South CBU Grid)
1	+100	+170	25	15	Target #3
2	+ 75	+130	(1)	15	Target #6
3	+110	+175	20	15	Target #4
4	+ 95	+160	25	15	Target #5

(1) The impact pattern plots show two distinct distributions. It must be assumed that they correspond to the two dispenser tubes fired. Dispenser tubes are fired in pairs, one tube on each side of the helicopter.

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 3	38	21	55%
2	BLU 3	38	23	61%
3	BLU 3	38	16	42%
4	BLU 3	38	17	45%

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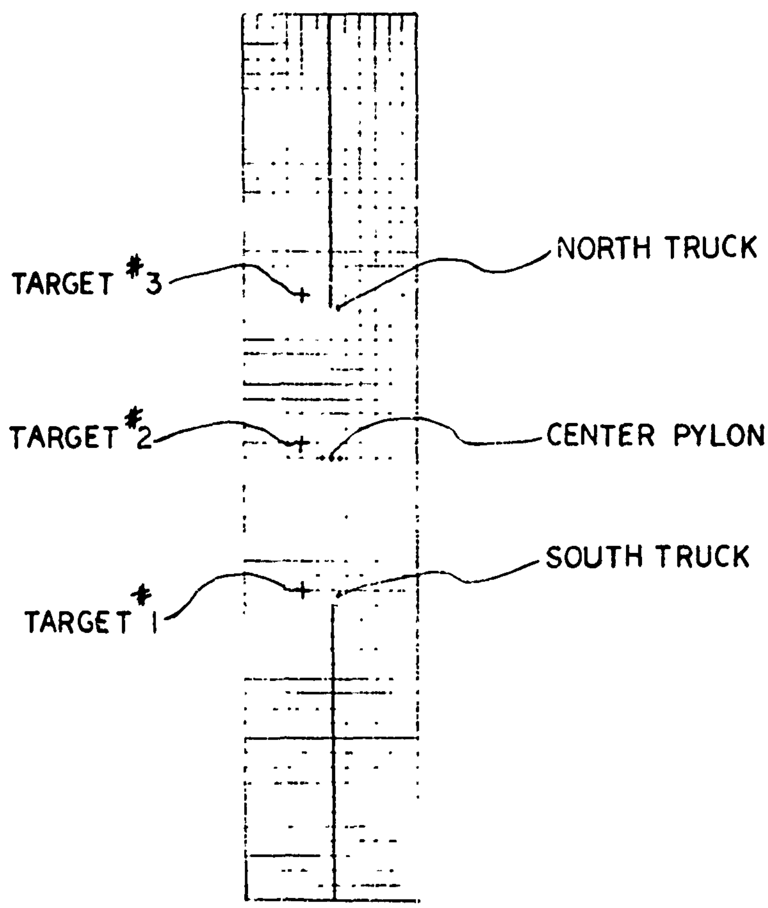
NORTH CBU GRID

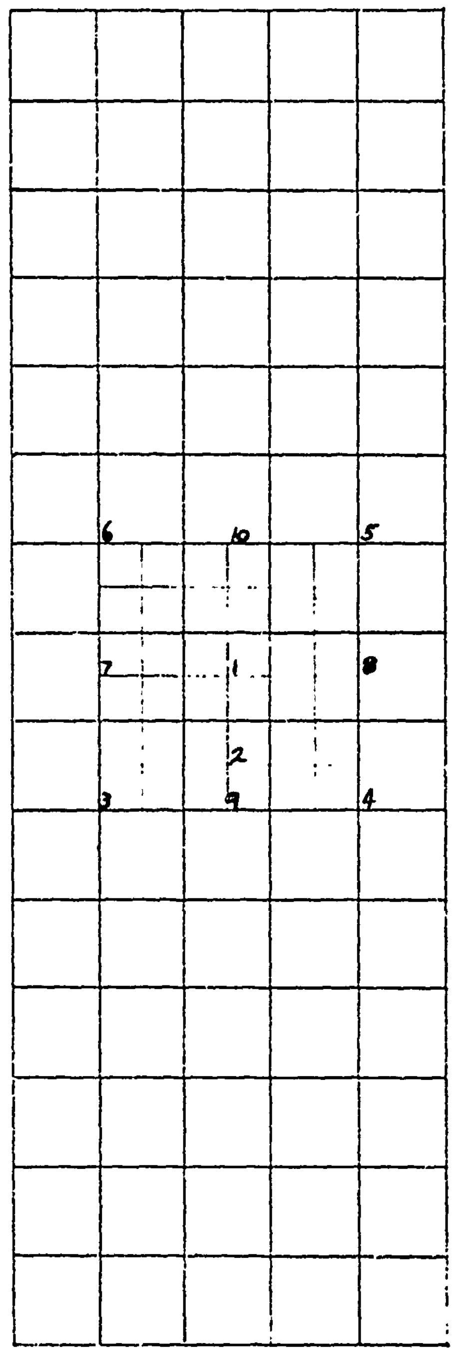
RANGE 3, NELLIS AFB, NEVADA



THE NORTH CBU GRID IS 6000' X 1200'. EACH SQUARE REPRESENTS 100 FT.

Figure C-1

SOUTH CBU GRID
RANGE 3, NELLIS AFB, NEVADA



THE SOUTH CBU GRID IS 3000' X 1000'. EACH SQUARE REPRESENTS 200', EXCEPT IN THE GRID CENTER WHICH IS SUBDIVIDED INTO 100' SQUARES.

Figure C-2

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BLU-3 BOMBLET TEST
Flight No. 3 Test No. 15
13 March 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution and dud rate data. One pair of dispenser tubes was fired on each of six runs at altitudes of 600 and 1,000 feet and airspeeds of 60 knots. Impact pattern dimensions were 80' x 30', 225' x 30', 150' x 30', 250' x 35', scattered, and 120' x 30'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter altitude and airspeed were not used. The dud rate was 11 percent. Flight duration was forty-two minutes.

Weather Conditions

Barometric Pressure: 26.83" Hg
Temperature: 68° F
Wind: 3 knots from 300° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	600	350°	90°	+ 4°
2	60	600	5°	90°	+14°
3	60	600	10°	90°	+ 5°
4	60	1000	10°	90°	+14°
5	60	1000	5°	89°	+ 5°
6	60	1000	5°	95°	0°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point $\overline{X}$ (feet)	Median Impact Point $\overline{Y}$ (feet)	Dispersion S_x (feet)	Dispersion S_y (feet)	Reference Target (South CBU Grid)
1	+260	+750	10	35	Target #3
2	+335	+655	10	70	Target #6
3	+370	+585	10	35	Target #2
4	+660	+485	10	(1)	Target #1
5	+440	+1560	15	(1)	Target #4
6	-365	+840	10	35	Target #5

(1) The impact pattern plots show two distinct distributions. It must be assumed that they correspond to the two dispenser tubes fired. Dispenser tubes are fired in pairs, one tube on each side of the helicopter.

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Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 3	38	2	5%
2	BLU 3	38	7	18%
3	BLU 3	38	5	13%
4	BLU 3	38	1	3%
5	BLU 3	38	4	11%
6	BLU 3	38	7	18%

BLU-3 BOMBLET TEST
Flight No. 4 Test No. 16
17 March 1970

(C) This test was conducted over the North CBU grid for the purpose of collecting hit distribution and dud rate data. One pair of dispenser tubes was fired on each of six runs at an airspeed of 30 knots and at altitudes ranging from 600 to 2,000 feet. Impact pattern dimensions were 170' x 50', 280' x 50', 210' x100', 225' x 35', 170' x 40' and 260' x 40'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter airspeed and altitude were not used. The dud rate was 13 percent. Flight duration was fifty-two minutes.

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	15°	94°	+14°
2	30	600	10°	80°	+19°
3	30	1000	290°	90°	0°
4	30	2000	360°	90°	-4°
5	30	2000	350°	85°	0°
6	30	2000	360°	90°	0°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point X (feet)	Median Impact Point Y (feet)	Dispersion S_x (feet)	Dispersion S_y (feet)	Reference Target (North CBU Grid)
1	-115	-100	15	55	Target #1
2	- 80	+335	45	200	Target #2
3	- 30	-190	30	50	Target #3
4	+130	-520	15	100	South Truck
5	-470	+280	20	45	Center Pylon
6	-235	-210	10	65	North Truck

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 3	38	11	29%
2	BLU 3	38	8	21%
3	BLU 3	38	6	16%
4	BLU 3	38	1	3%
5	BLU 3	38	2	5%
6	BLU 3	38	2	5%

BLU-3 BOMBLET TEST
Flight No. 5 Test No. 15A
18 March 1970

(C) This test was conducted over the North CBU grid for the purpose of collecting hit distribution and dud rate data. One pair of dispenser tubes was fired on each of six runs at an airspeed of 60 knots and at altitudes ranging from 600 to 2,000 feet. Impact pattern dimensions were 170' x 50', 280' x 50', 210' x 100', 225' x 35', 170' x 40' and 260' x 40'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter airspeed and altitude were not used. The dud rate was 5 percent. Flight duration was fifty minutes.

Weather Conditions

Barometric pressure: 26.82" Hg
Temperature: 58° F
Wind: 6 knots from 330 ° T

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Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	600	5°	92°	+5°
2	60	1000	30°	90°	+8°
3	60	1000	5°	90°	+8°
4	60	2000	20°	90°	-2°
5	60	2000	10°	90°	-2°
6	60	2000	355°	90°	-2°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point $\overline{X}$ (feet)	$\overline{Y}$ (feet)	Dispersion S_X (feet)	S_Y (feet)	Reference Target (North CBU Grid)
1	- 25	-185	(1)	(1)	200' left of Target #1
2	-110	-350	10	55	200' left of Target #2
3	-105	-875	15	10	200' left of Target #3
4	+ 15	-115	30	35	200' right of South Truck
5	+ 15	-620	25	100	200' right of Center Pylon
6	+ 15	+ 65	15	60	200' right of North Truck

(1) The impact pattern plots show two distinct distributions. It must be assumed that they correspond to the two dispenser tubes fired. Dispenser tubes are fired in pairs, one tube on each of the helicopter.

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 3	38	4	11%
2	BLU 3	38	1	3%
3	BLU 3	38	3	8%
4	BLU 3	38	0	0%
5	BLU 3	38	2	5%
6	BLU 3	38	2	5%

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BLU-3 BOMBLET TEST
Flight No. 6 Test No. 18A
18 March 1970

(C) This test was conducted over the North CBU grid for the purpose of collecting hit distribution and dud rate data. Three pair of dispenser tubes were ripple fired (fired in rapid succession) at an altitude of 600 feet and an airspeed of 30 knots. The resulting impact pattern dimensions were 200' x 50'. The target was used as an aimpoint reference only. Aimpoint offsets to correct bomblet trajectories for helicopter altitude and airspeed were not used. The dud rate was 18 percent.

(C) As a result of ripple firing three pair of tubes, the helicopter pitched up 15 degrees and pitch control was temporarily lost. This test demonstrated ripple firing to be unfeasible. No more ripple firings were attempted. Flight duration was twenty-two minutes.

Weather Conditions

Barometric pressure: 26.78" Hg
Temperature: 58° F
Wind: 10 knots from 310° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	25°	90°	-12°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point $\overline{X}$ (feet)	$\overline{Y}$ (feet)	Dispersion S_x (feet)	S_y (feet)	Reference Target (North CBU Grid)
1	-30	-240	35	50	200' beyond Center Pylon

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 3	114	20	18%

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BLU-3 BOMBLET TEST
Flight No. 7 Test No. 21
19 March 1970

(C) This test was conducted over the North CBU grid for the purpose of collecting hit distribution and dud rate data. One pair of dispenser tubes was fired on each of three runs at airspeeds of 30 knots and an altitude of 3,000 feet. Hit distribution and dud rate data were not obtained. Flight duration was forty-five minutes.

Weather Conditions

Barometric pressure: 26.85" Hg
Temperature: 61° F
Wind: 8 knots from 320° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	3000	15°	90°	+4°
2	30	3000	15°	90°	+4°
3	30	3000	0°	90°	0°

Hit Distribution Data (Title Unclassified)

Not available.

Bomblet Dud Rate Data (Title Unclassified)

Not available.

BLU-3 BOMBLET TEST
Flight No. 8 Test No. 20
20 March 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution, dud rate and mid-air collision data. One pair of dispenser tubes was fired on each of four runs executed at airspeeds of 30 and 60 knots and at altitudes of 600 and 1,000 feet. The bomblets from the first run were scattered. The impact pattern dimensions for the other runs were 120' x 30', 100' x 40' and 90' x 35'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter airspeed and altitude were not used. The dud rate was 3 percent. No mid-air collisions were observed, however film coverage was too

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sporadic to make an evaluation. Flight duration was fort-- 'ive minutes.

Weather Conditions

Barometric pressure: 26.89" Hg
Temperature: 61° F
Wind: 4 knots from 300 ° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	600	45°	90°	+18°
2	30	600	350°	90°	- 3°
3	60	1000	350°	90°	- 4°
4	30	1000	5°	90°	0°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point $\overline{X}$ (feet)	$\overline{Y}$ (feet)	Dispersion S_x (feet)	S_y (feet)	Reference Target (South CBU Grid)
1	+370	+770	20	25	Target #3
2	+405	+465	10	45	Target #6
3	+255	+825	15	25	Target #1
4	N/A	N/A	15	25	Target #4

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 27	38	2	5%
2	BLU 27	38	2	5%
3	BLU 27	38	0	0
4	BLU 27	38	0	0

BLU-3 BOMBLET TEST
Flight No. 9 Test No. 20
20 March 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution, dud rate and mid-air collision data. One pair of dispenser tubes was fired on each of two runs at airspeeds of 60 and 30 knots

and at an altitude of 2,000 feet. The impact pattern dimensions were 185' x 50' and 155' x 50'. Targets were used as aimpoint references only. Aimpoint offsets to correct bomblet trajectories for helicopter airspeed and altitude were not used. The dud rate was 3 percent. No mid-air collisions were observed, however film coverage was too sporadic to make an evaluation. Flight duration was twenty-one minutes.

Weather Conditions

Barometric pressure: 26.89" Hg
Temperature: 61° F
Wind: 4 knots from 300° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	2000	0°	90°	+2°
2	30	2000	0°	90°	-2°

Hit Distribution Data (Title Unclassified/Table Confidential)

Run No.	Median Impact Point $\overline{X}$ (feet)	Median Impact Point $\overline{Y}$ (feet)	Dispersion S_x (feet)	Dispersion S_y (feet)	Reference Target (South CBU Grid)
1	+255	+760	20	50	Target #5
2	+420	+230	20	35	Target #2

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU 27	38	2	5%
2	BLU 27	38	0	0

CHECK FLIGHT
Flight No. 10 Test No. -
9 June 1970

(U) This test was a check flight to insure that all systems were ready for the BLU-24 and BLU-26 bomblet tests. Mount vibration was experienced at small depression angles, but none at 90° depression. All systems checked out satisfactorily. Flight duration was twenty-two minutes.

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BLU-26 BOMBLET TEST
Flight No. 11 Test No. 122
10 June 1970

(C) This test consisted of five runs dispensing BLU-26 bomblets against pylon targets for the purpose of collecting dud rate data. The dud rate was almost 100 percent. Flight duration was fifty-five minutes.

Weather Conditions

Barometric pressure: 26.40" Hg
Temperature: 65° F
Wind: 10 knots from 240° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	1000	32° T	90°	0°
2	30	1500	4° T	90°	0°
3	60	1500	4° T	90°	0°
4	60	2000	360° T	90°	0°
5	30	2000	360° T	90°	0°

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1 - 5	BLU 26	250	-	Almost 100%

BLU-24 BOMBLET TEST
Flight No. 12 Test No. 120
11 June 1970

(C) This test consisted of three runs dispensing BLU-24 bomblets against pylon targets for the purpose of collecting dud rate data. Due to a dispenser loading error, only one side fired. A large yaw excursion was experienced. The dud rate was 8 percent. Flight duration was forty-one minutes.

Weather Conditions

Barometric pressure: 26.58" Hg
Temperature: 56° F
Wind: 6 knots from 220° T

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Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	1000	14° T	90°	+5°
2	60	1500	14° T	90°	+2°
3	60	2000	354° T	90°	0°

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU-24	21	4	19%
2	BLU-24	21	0	0
3	BLU-24	21	1	5%

BLU-24 BOMBLET TEST
Flight No. 13 Test No. 121
11 June 1970

(C) This test consisted of three runs dispensing BLU-24 bomblets over pylon targets for the purpose of collecting dud rate data. The dud rate was 17 percent. Flight duration was thirty-one minutes.

Weather Conditions

Barometric pressure: 26.60" Hg
Temperature: 69° F
Wind: 4 knots from 240° T

Flight and Mount Parameters (Title Unclassified/Table Confidential)

Run No.	Airspeed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	1000	12° T	90°	+8°
2	30	1500	330° T	90°	-3°
3	30	2000	16° T	90°	+2°

Bomblet Dud Rate Data (Title Unclassified/Table Confidential)

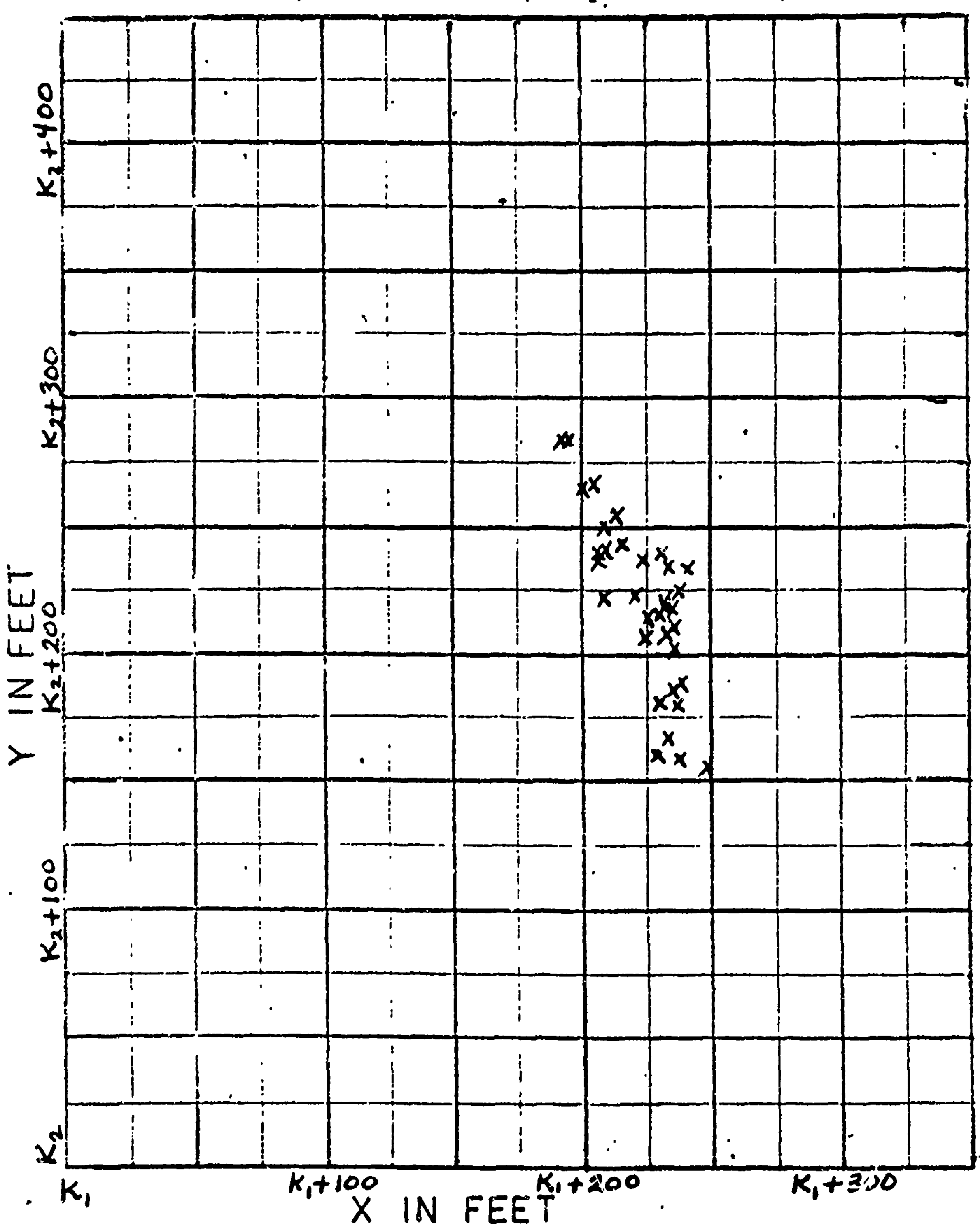
Run No.	Bomblet Type	No. of Bomblets Dispensed	No. of Duds	Dud Rate
1	BLU-24	42	2	5%
2	BLU-24	42	0	0
3	BLU-24	42	20	48%

CONFIDENTIAL.

BOMBLET IMPACT PATTERN

TEST NO. 14-1

(Title Unclassified/Graph Confidential)



CONFIDENTIAL

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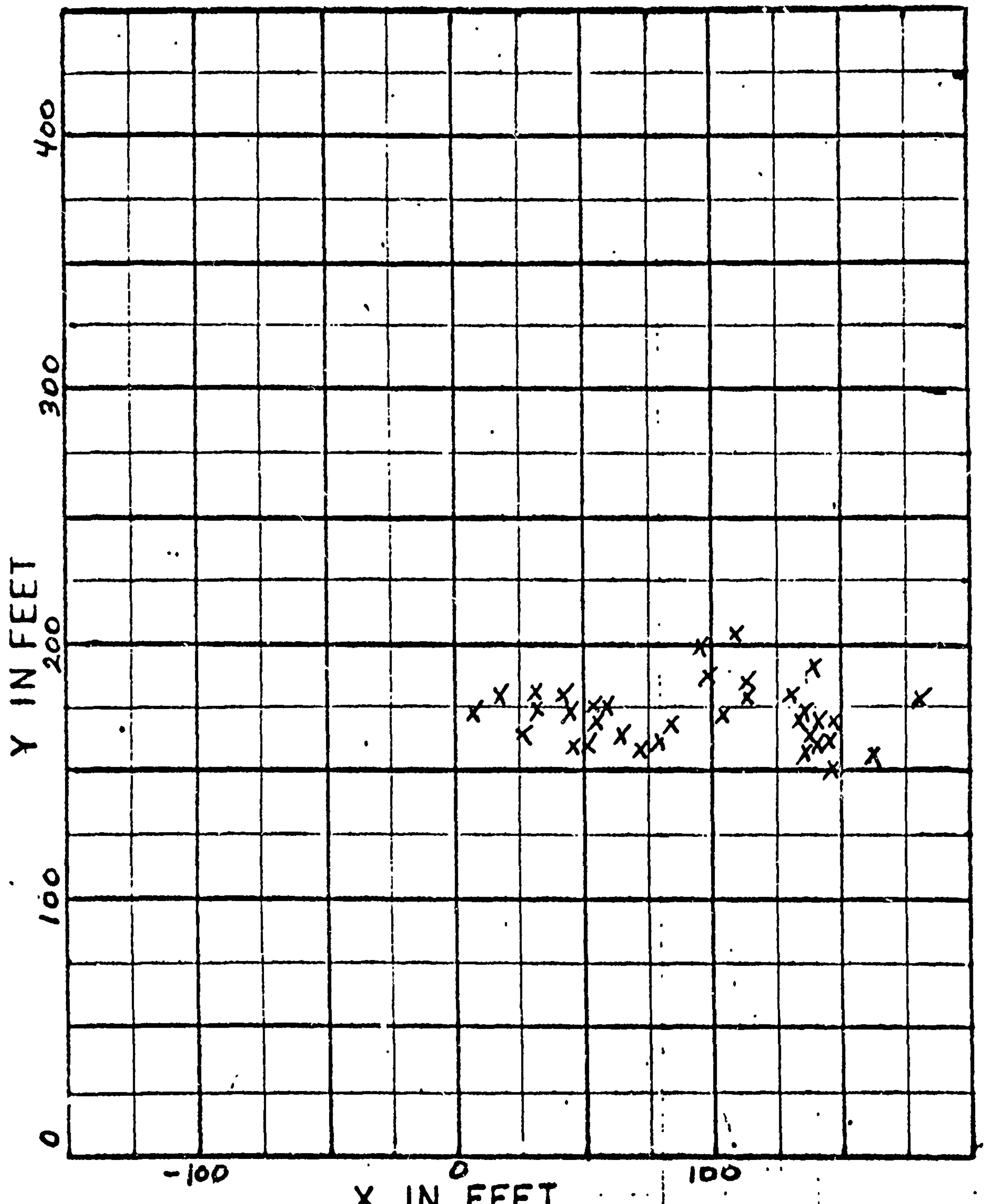

8-C16

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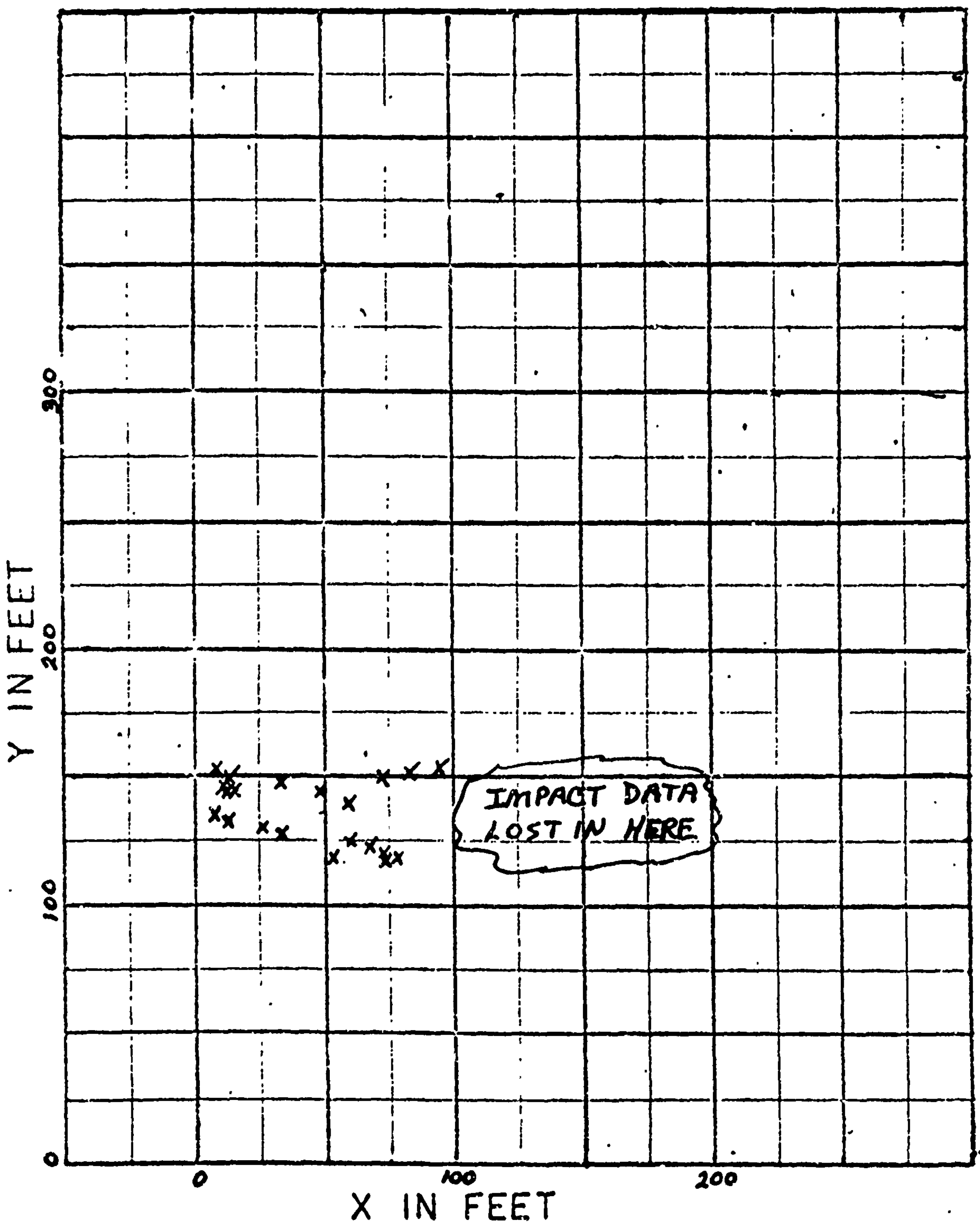

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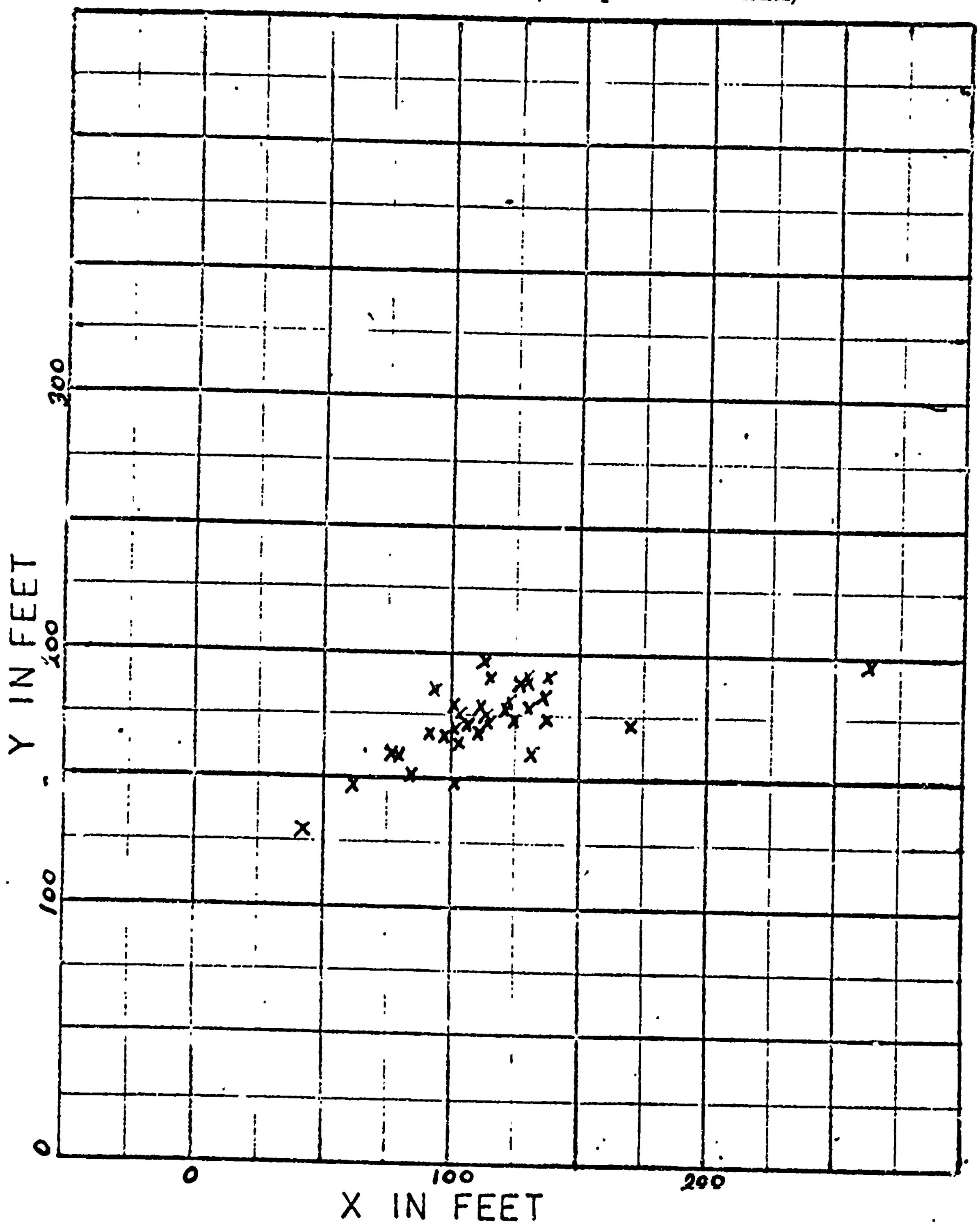

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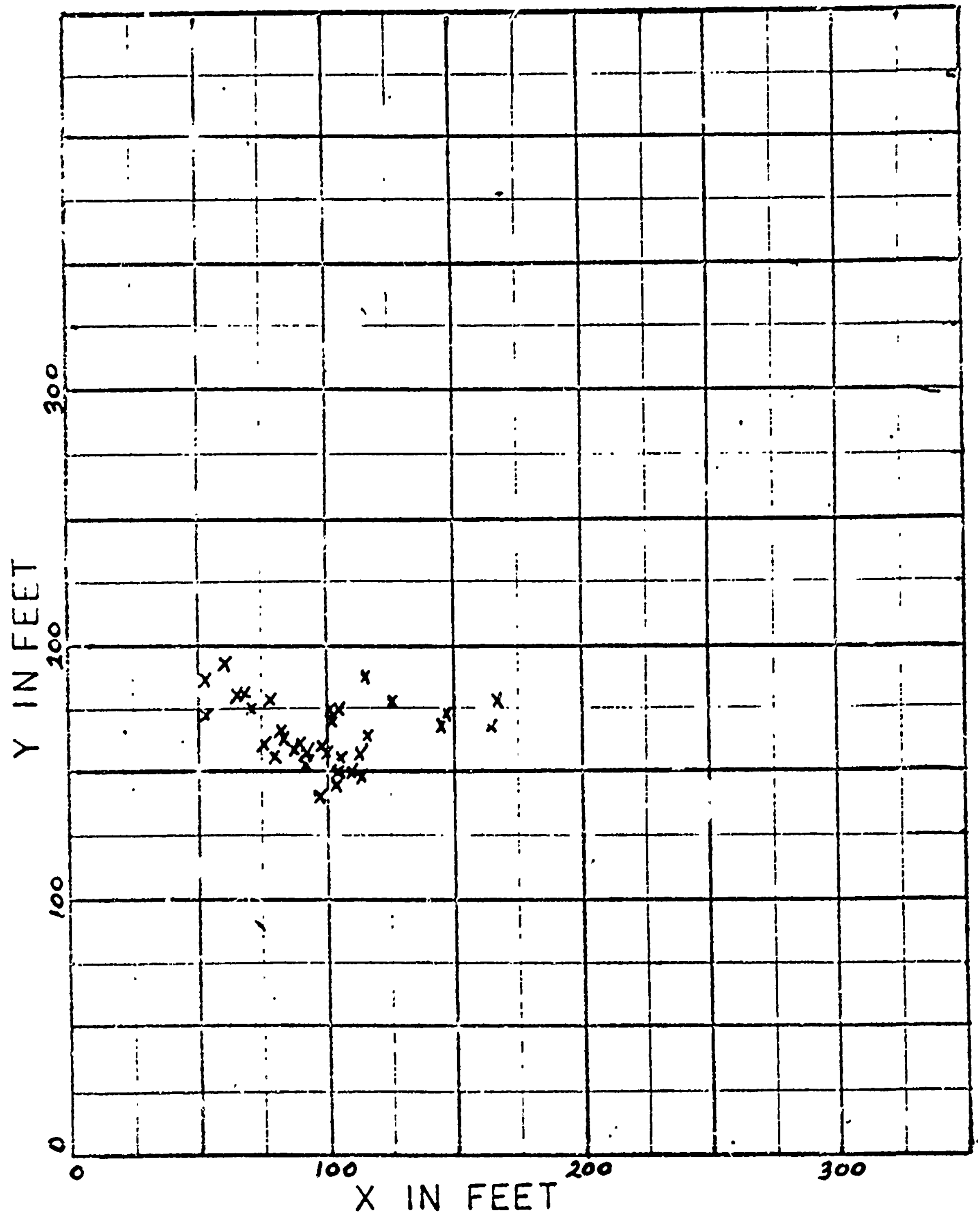

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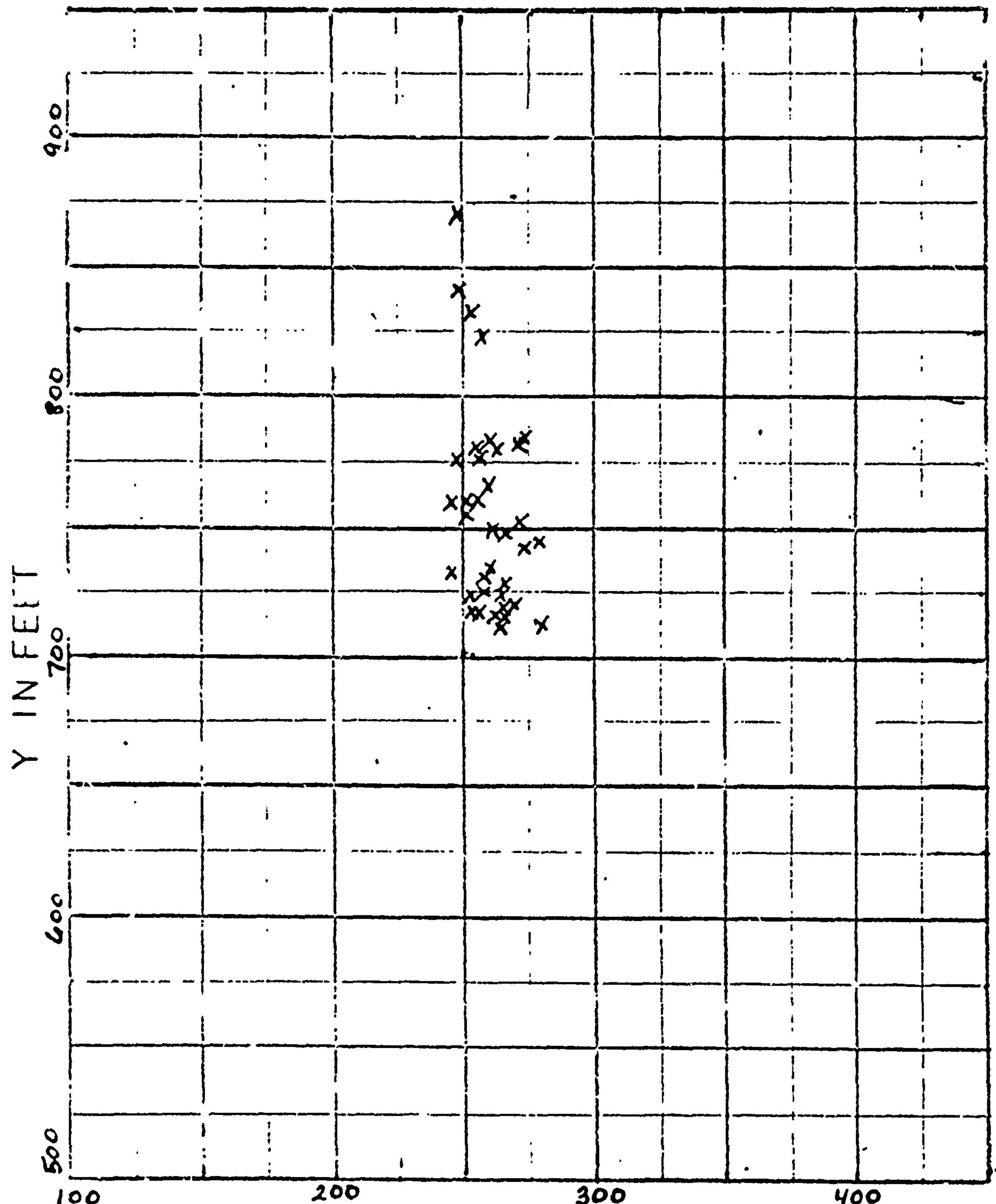

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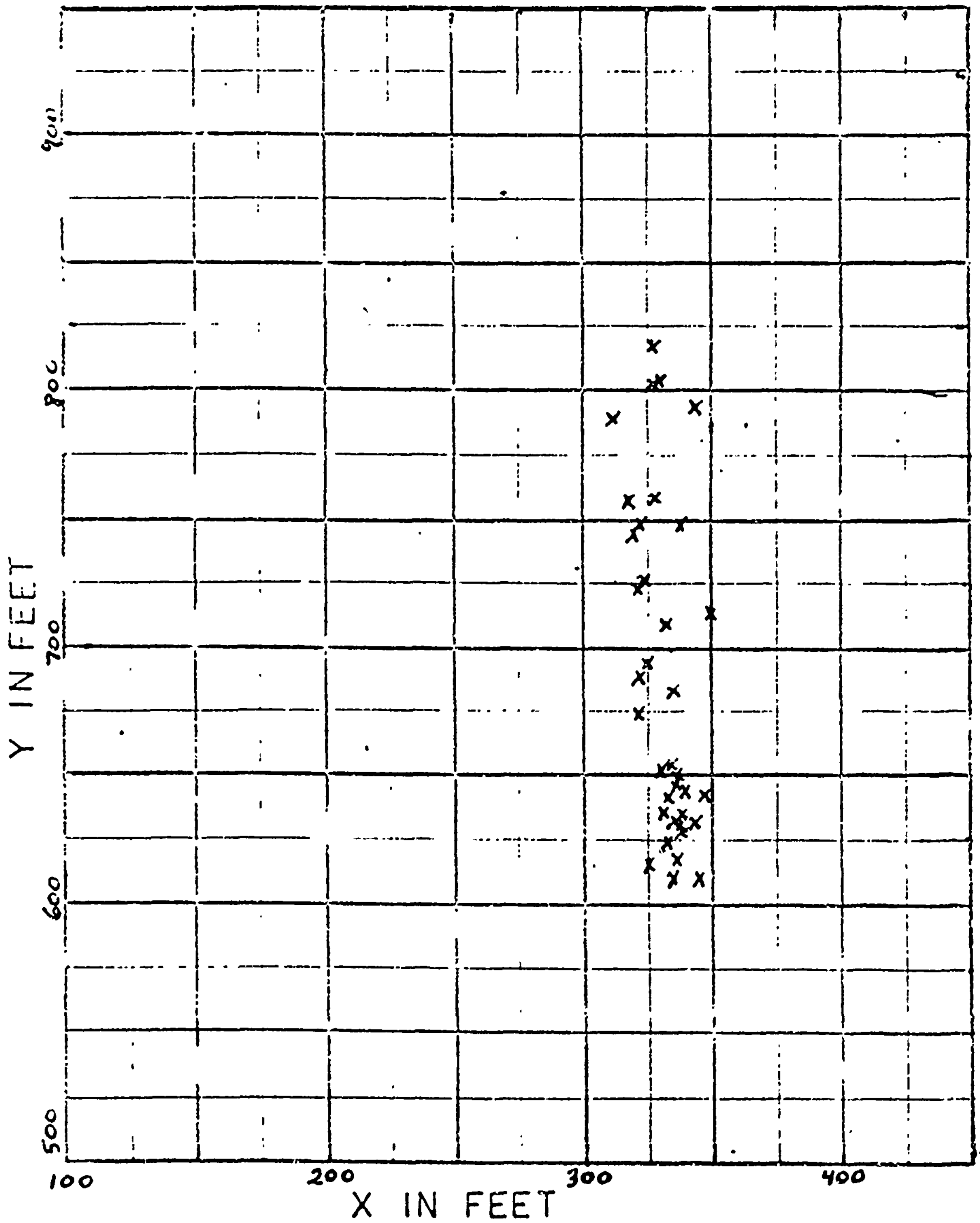

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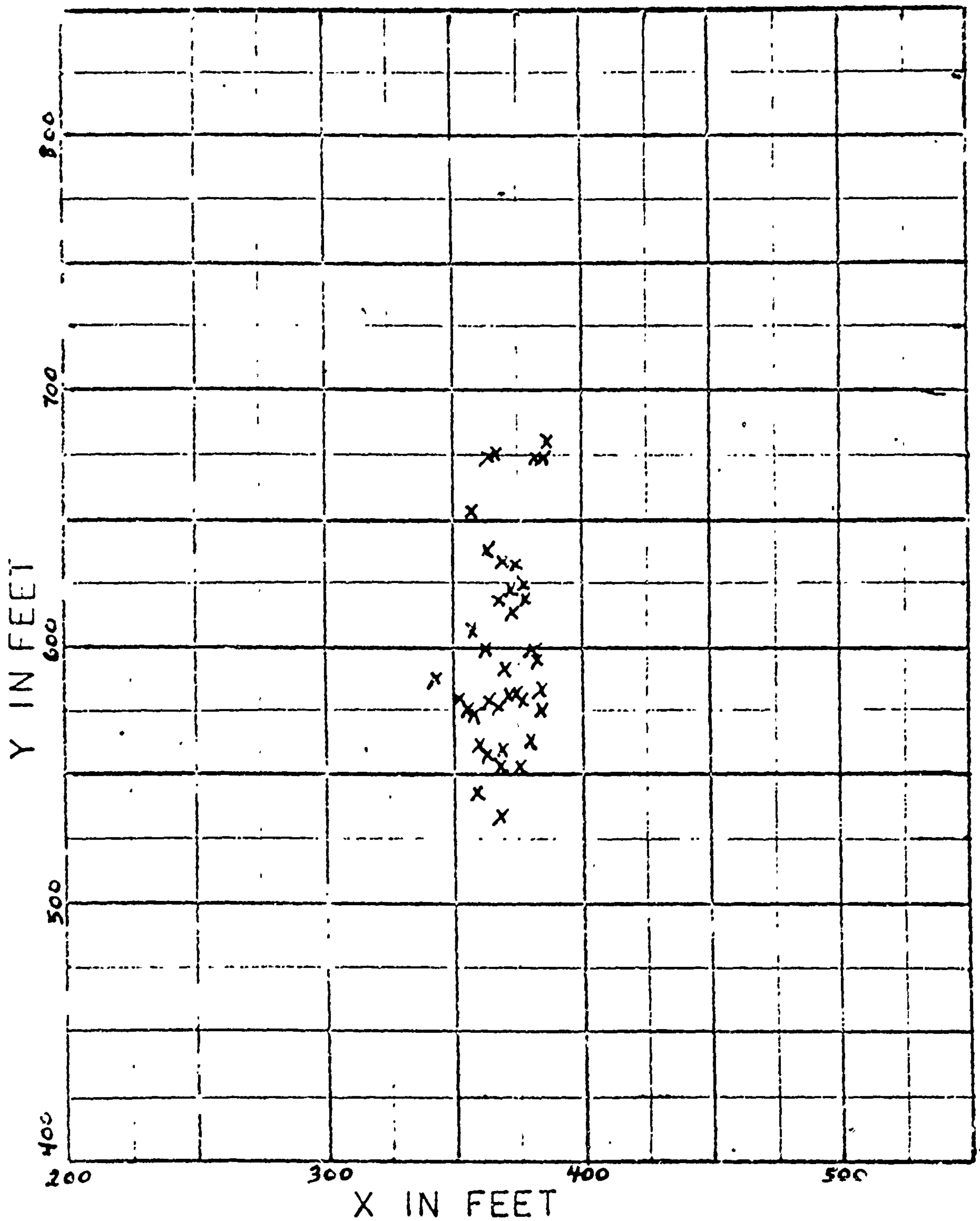

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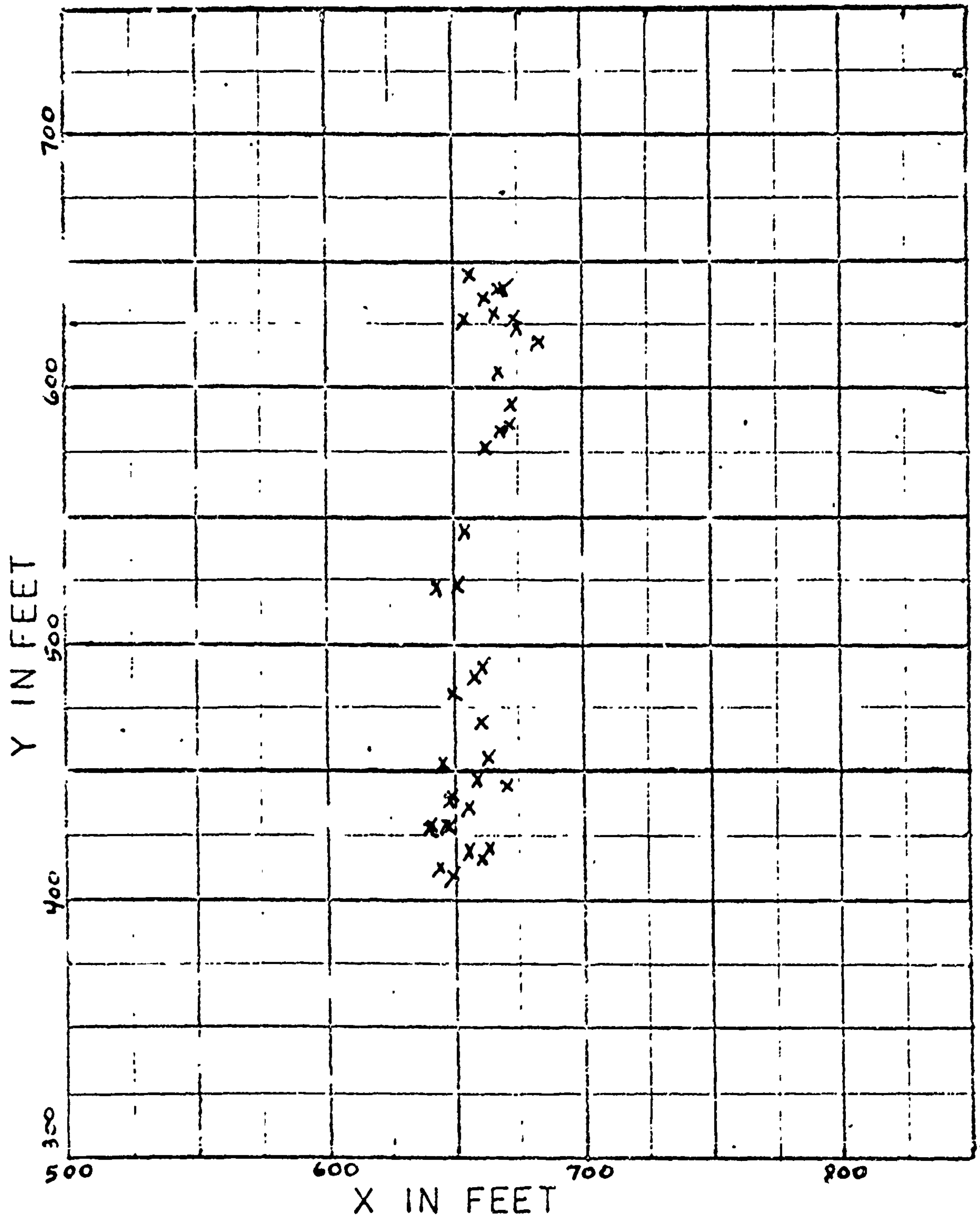

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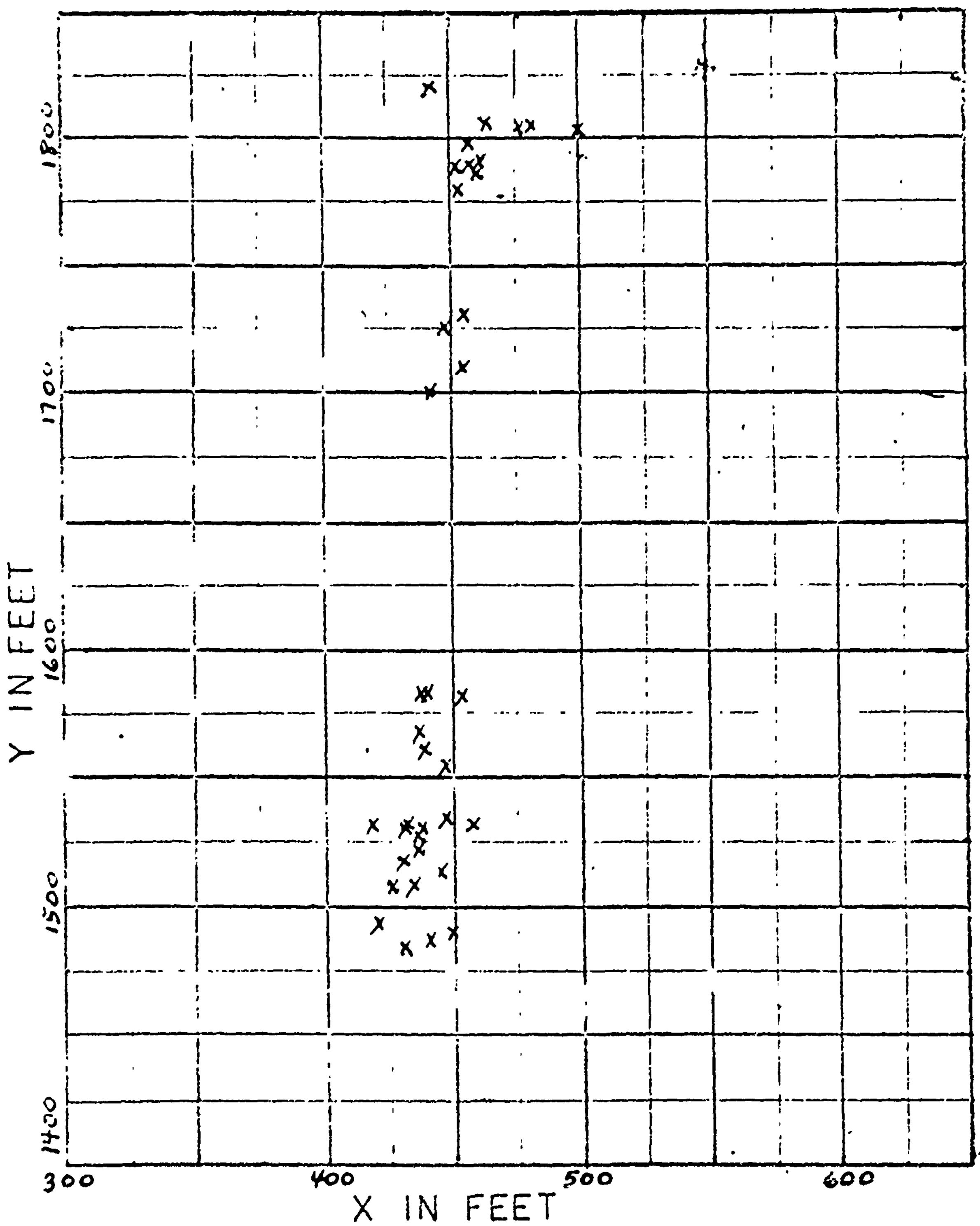

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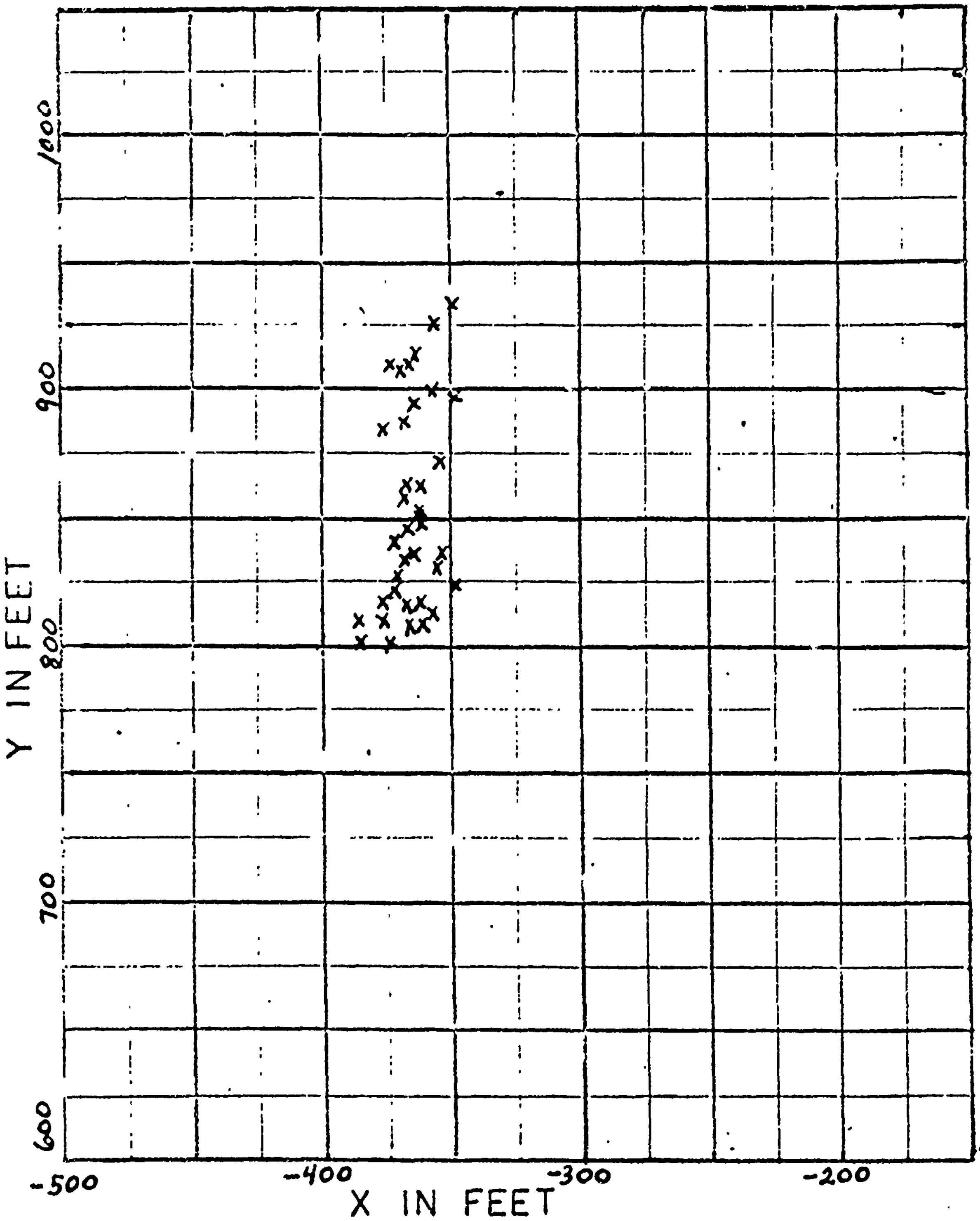

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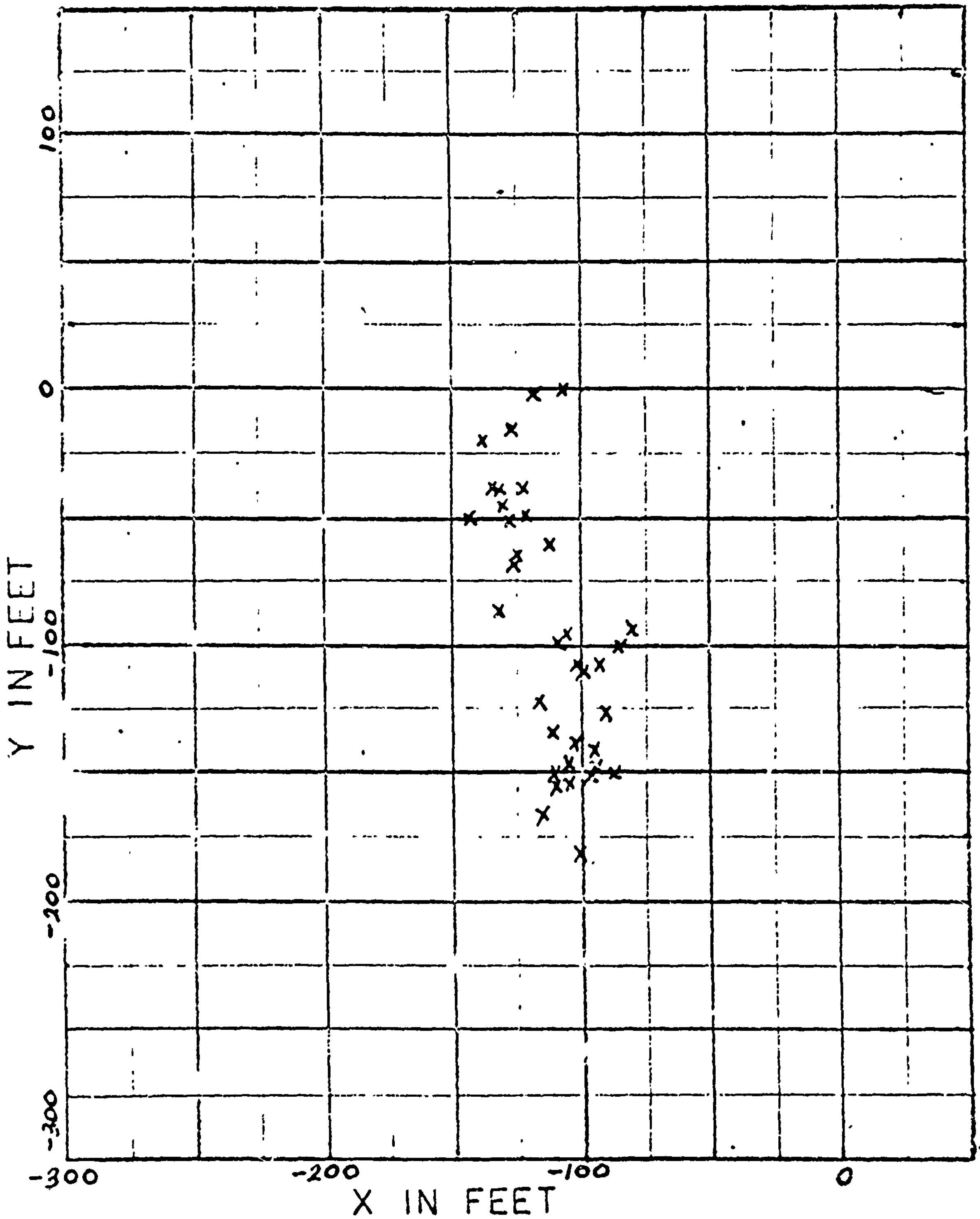

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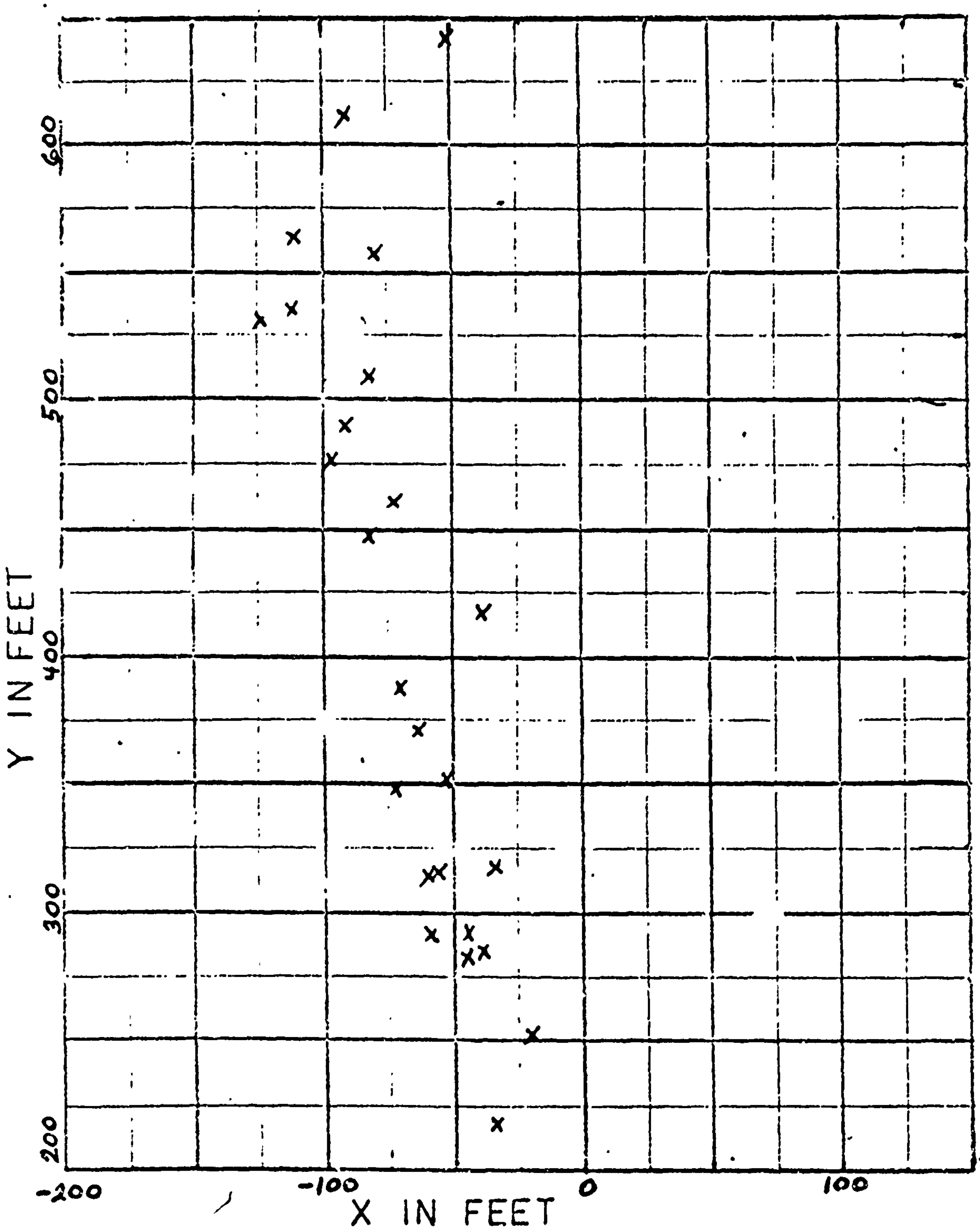

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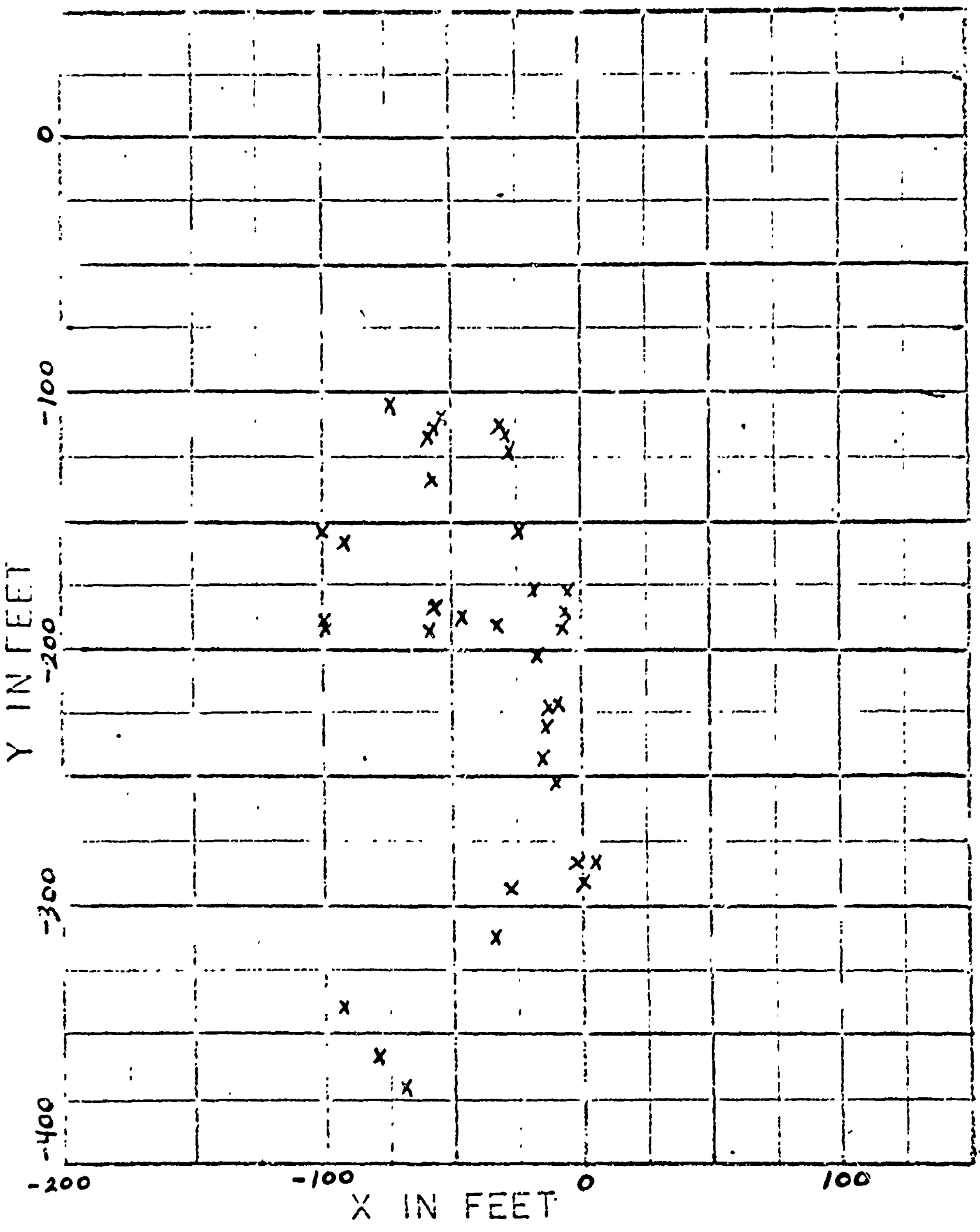

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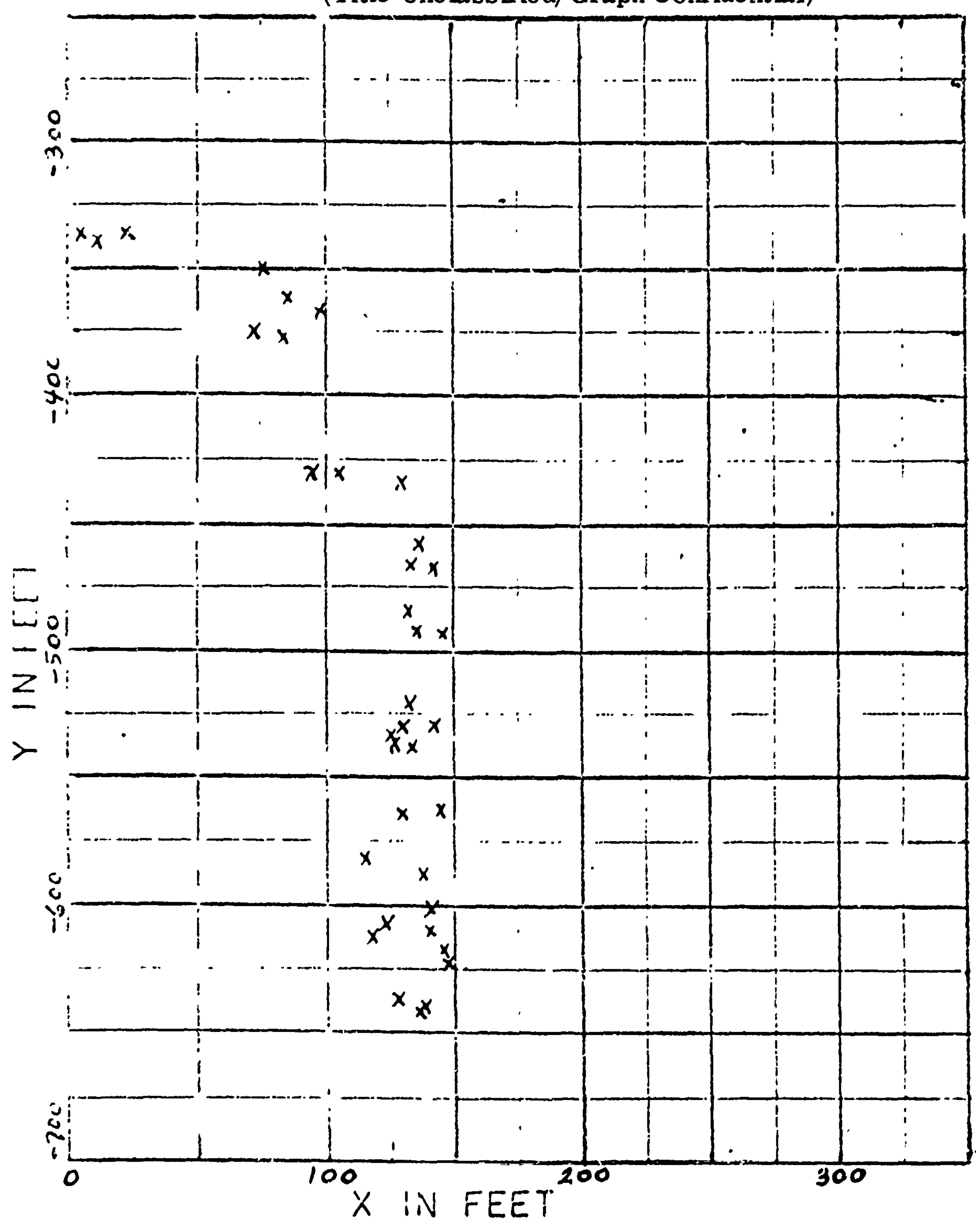

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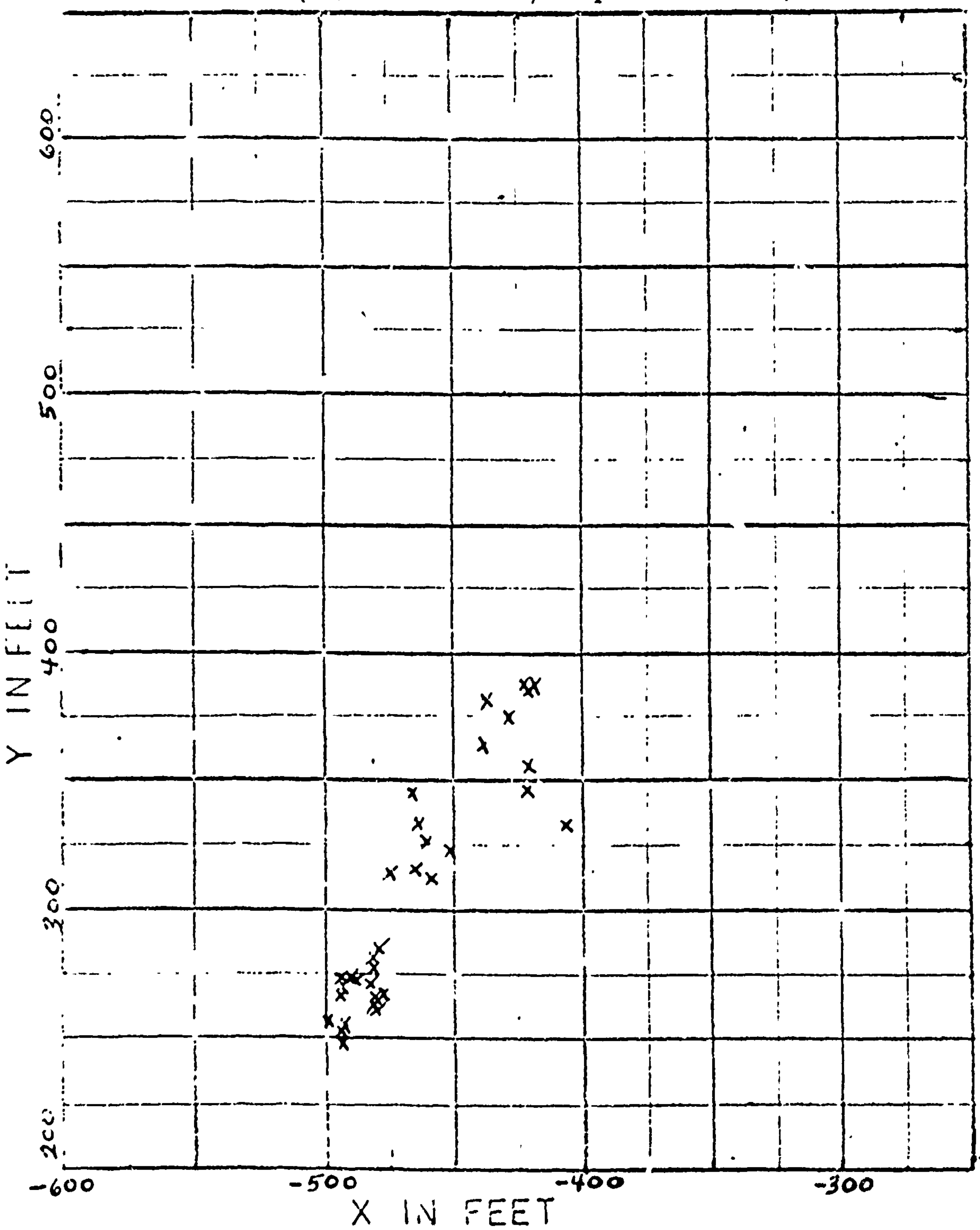

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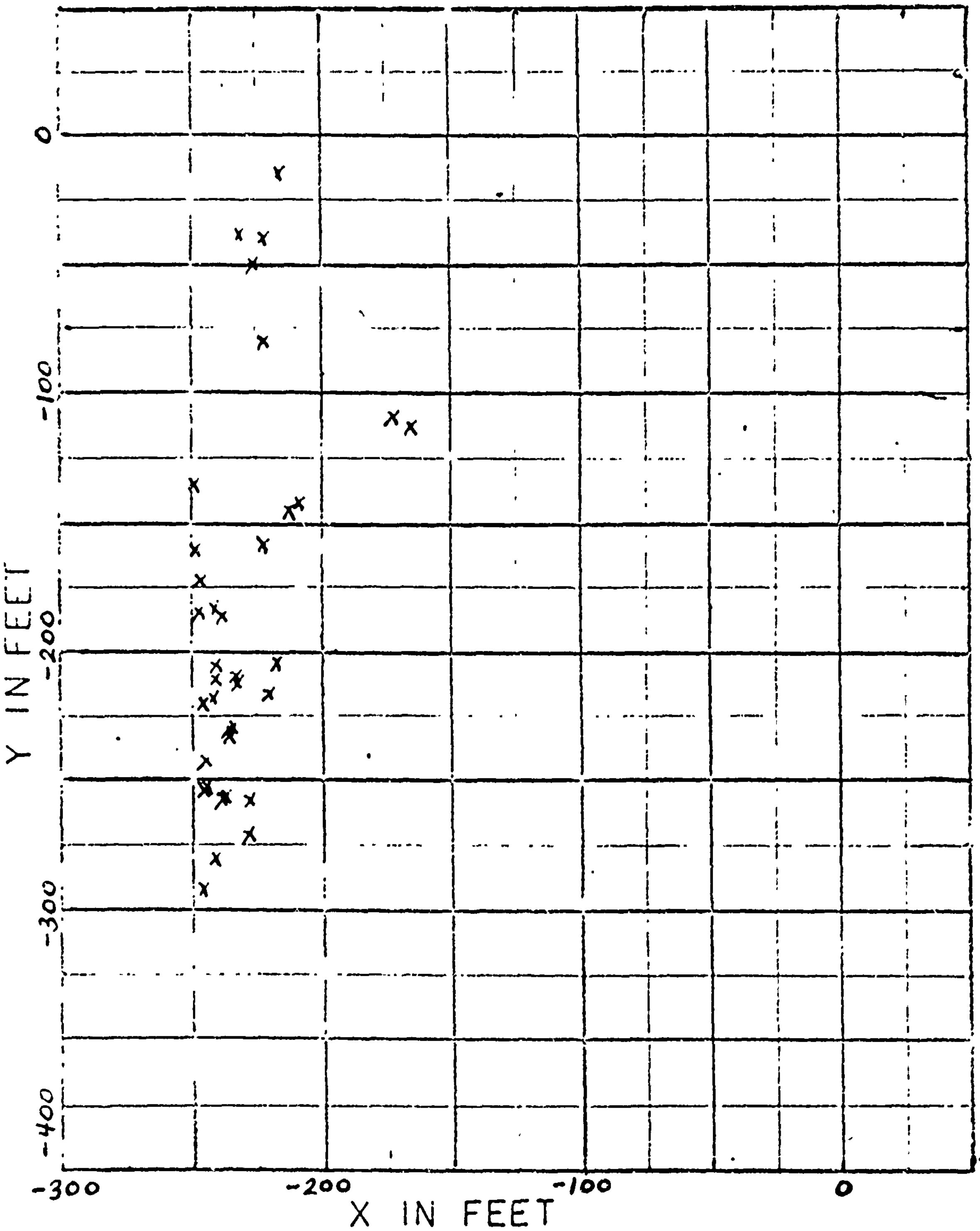

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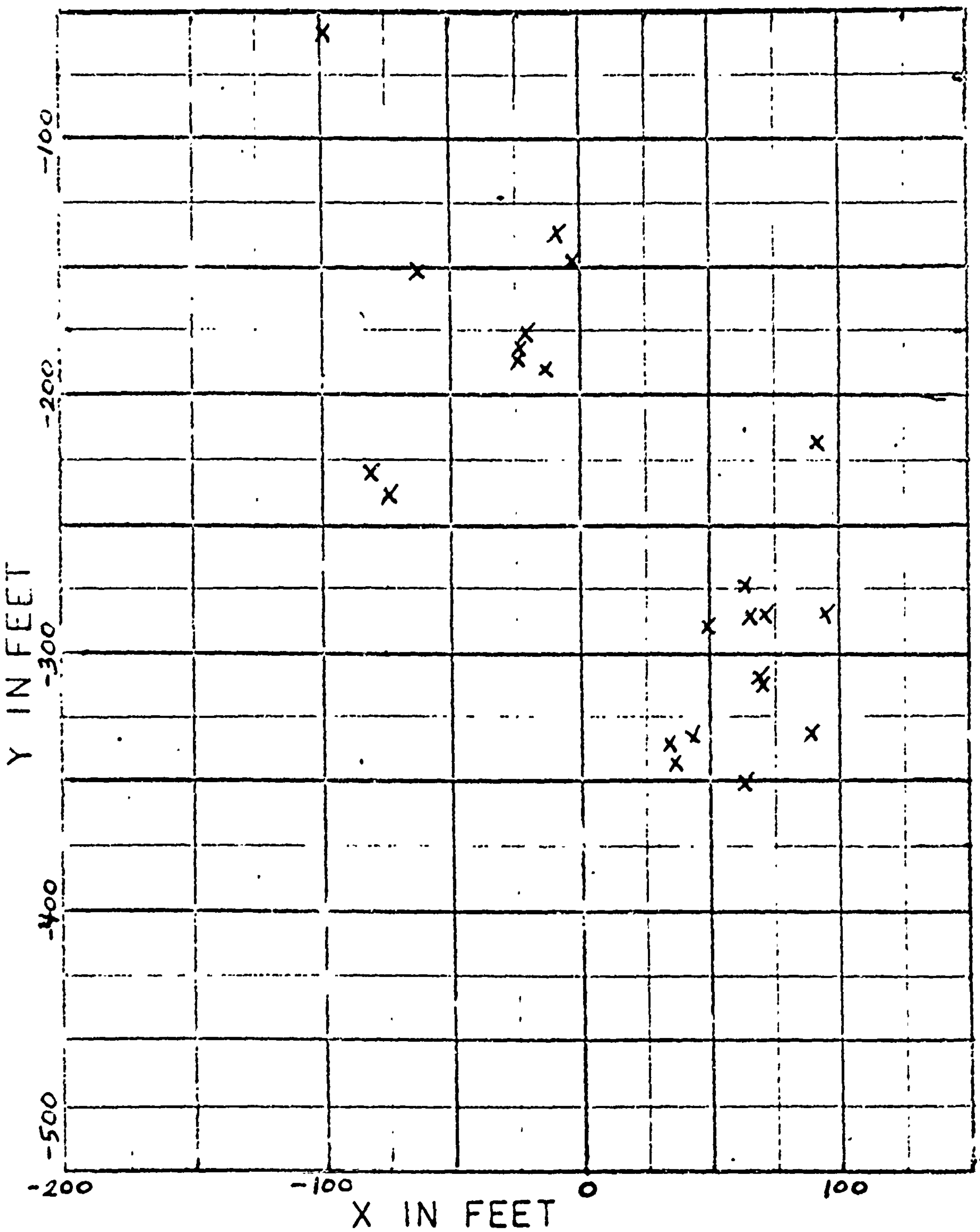

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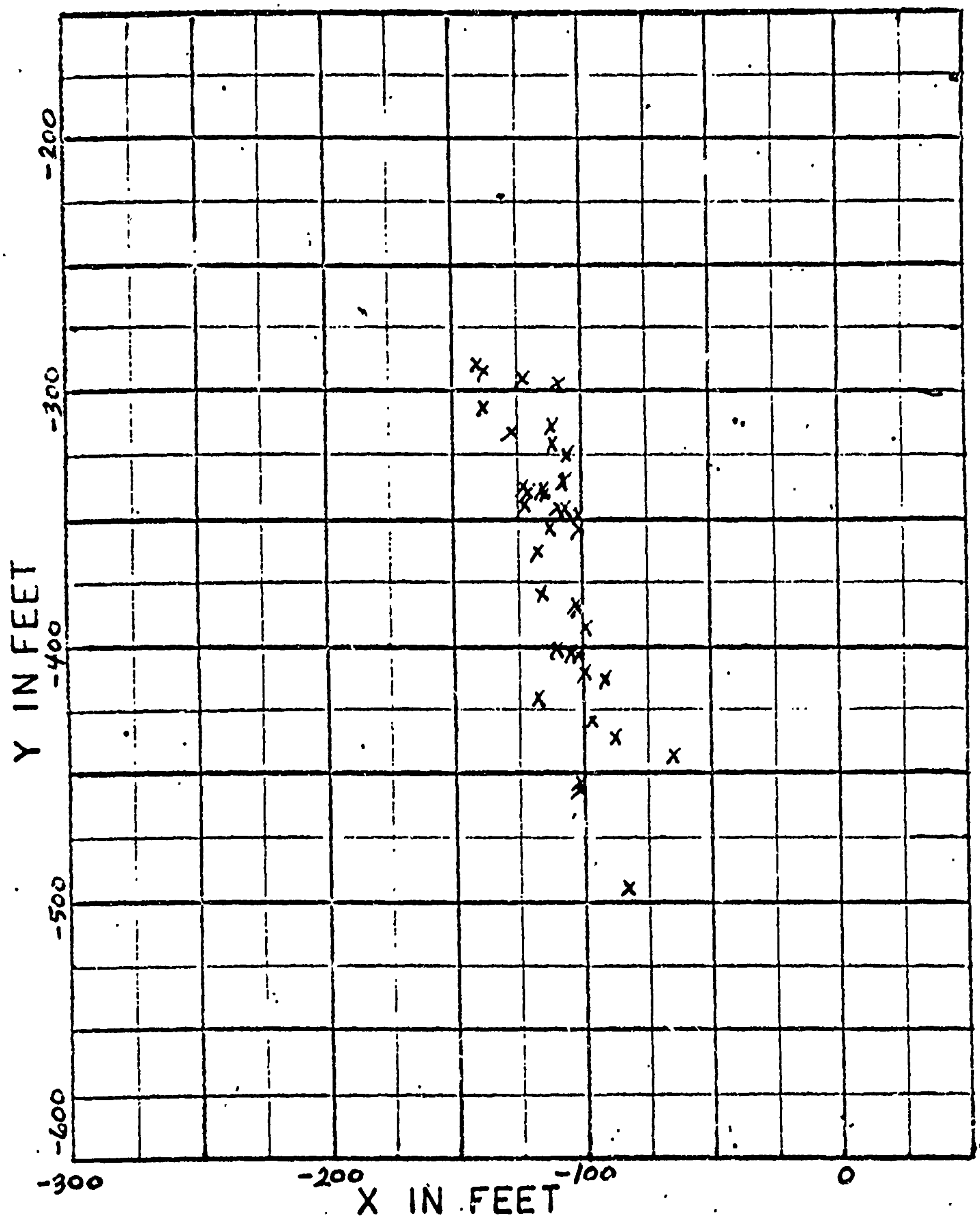

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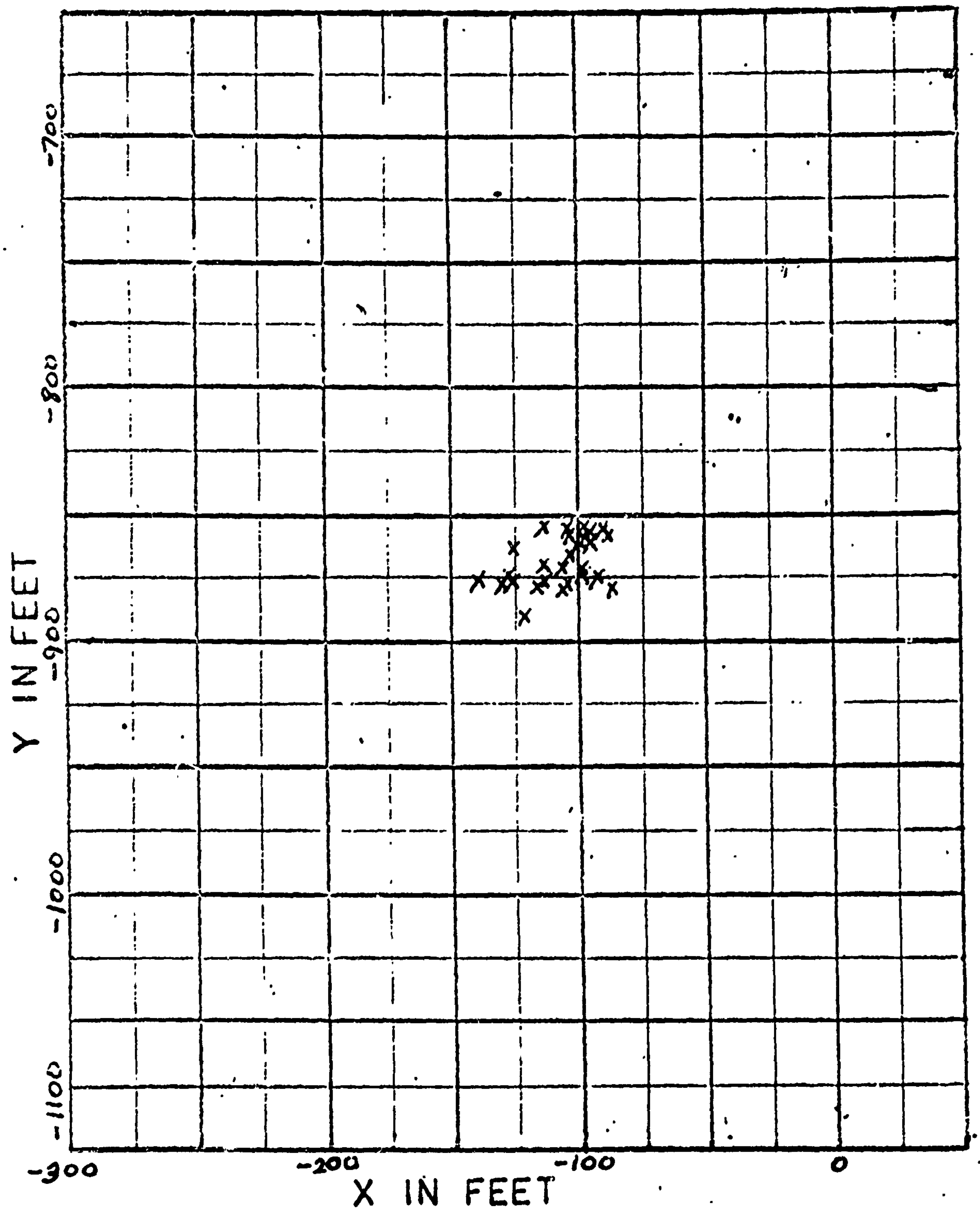

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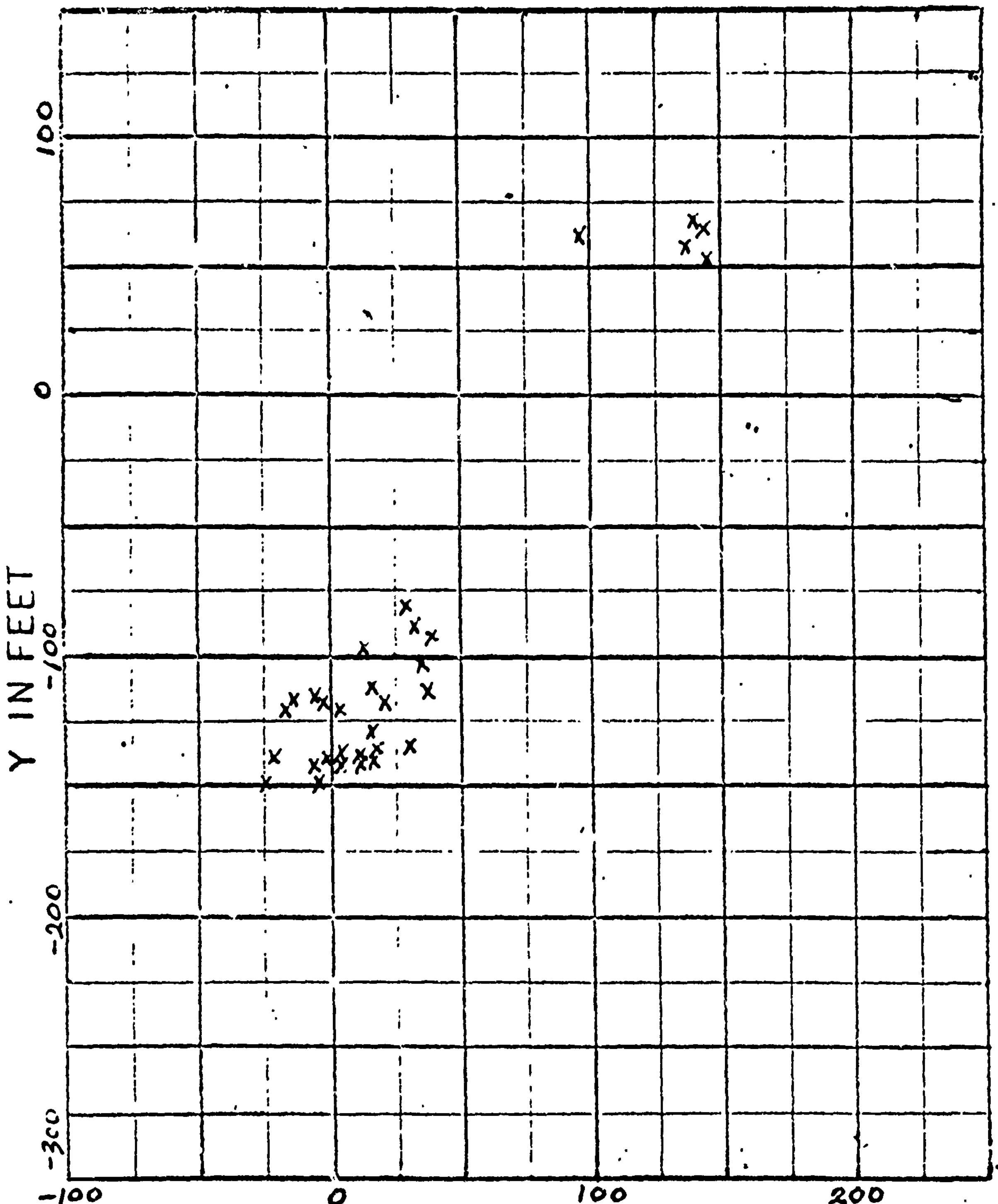

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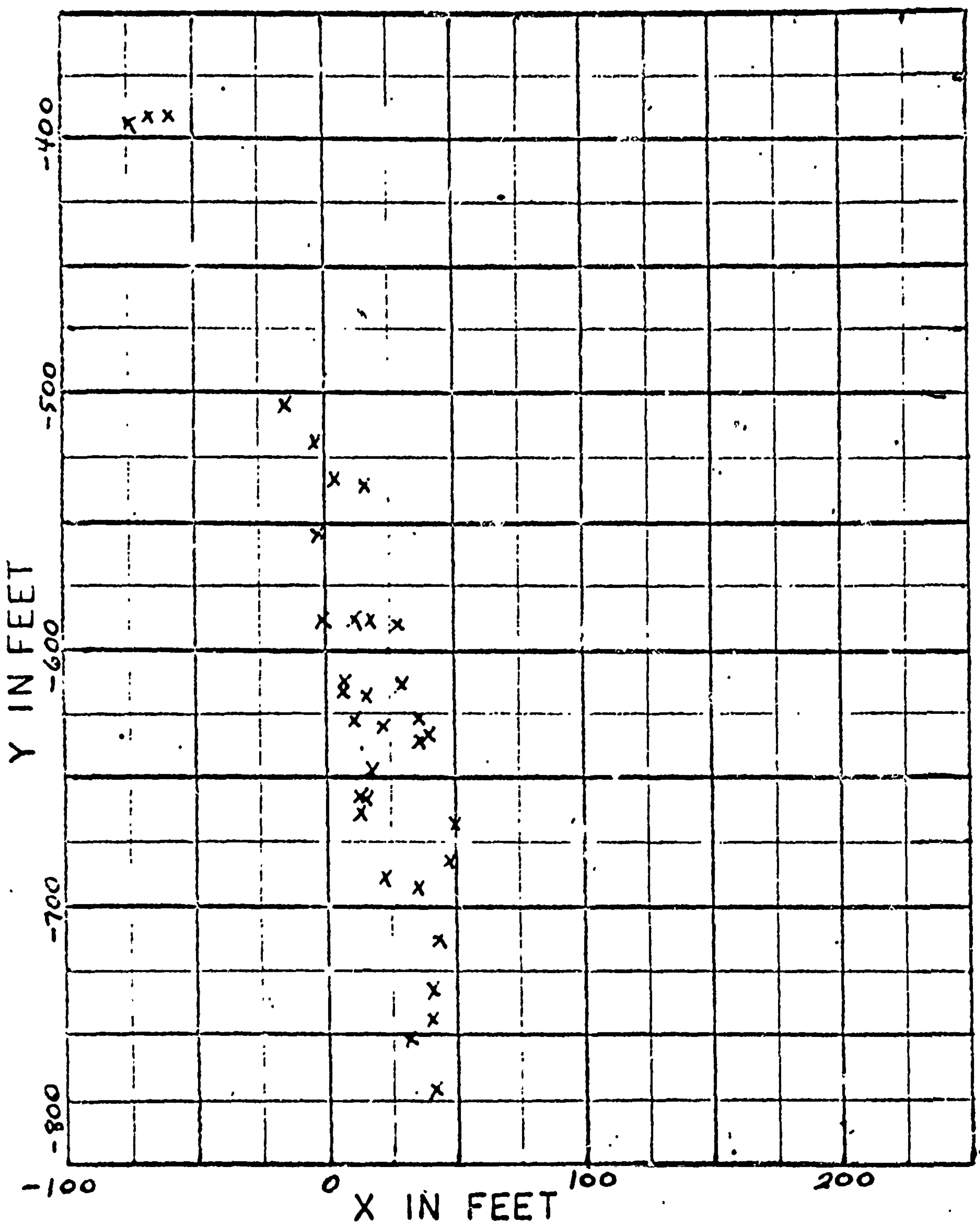

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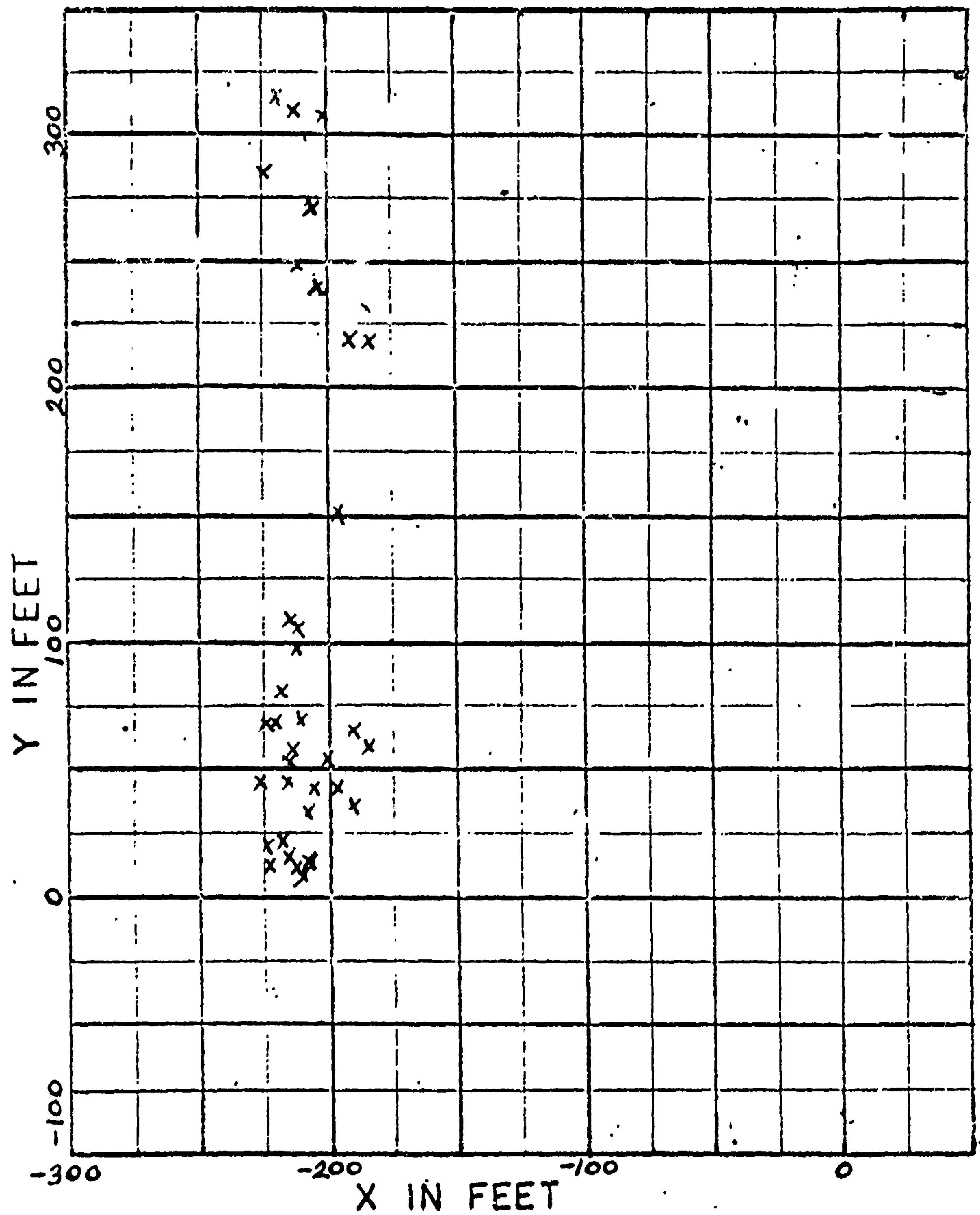

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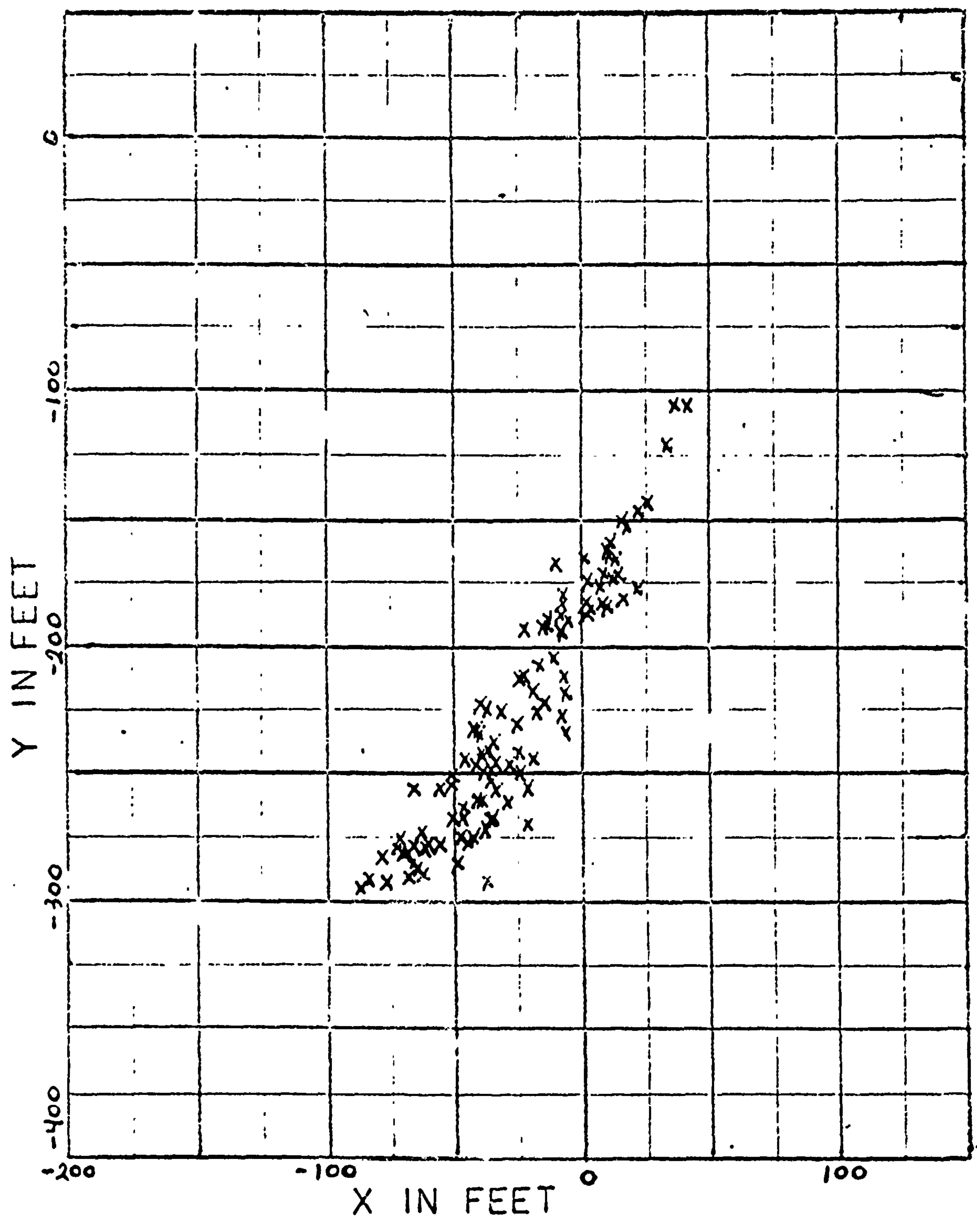

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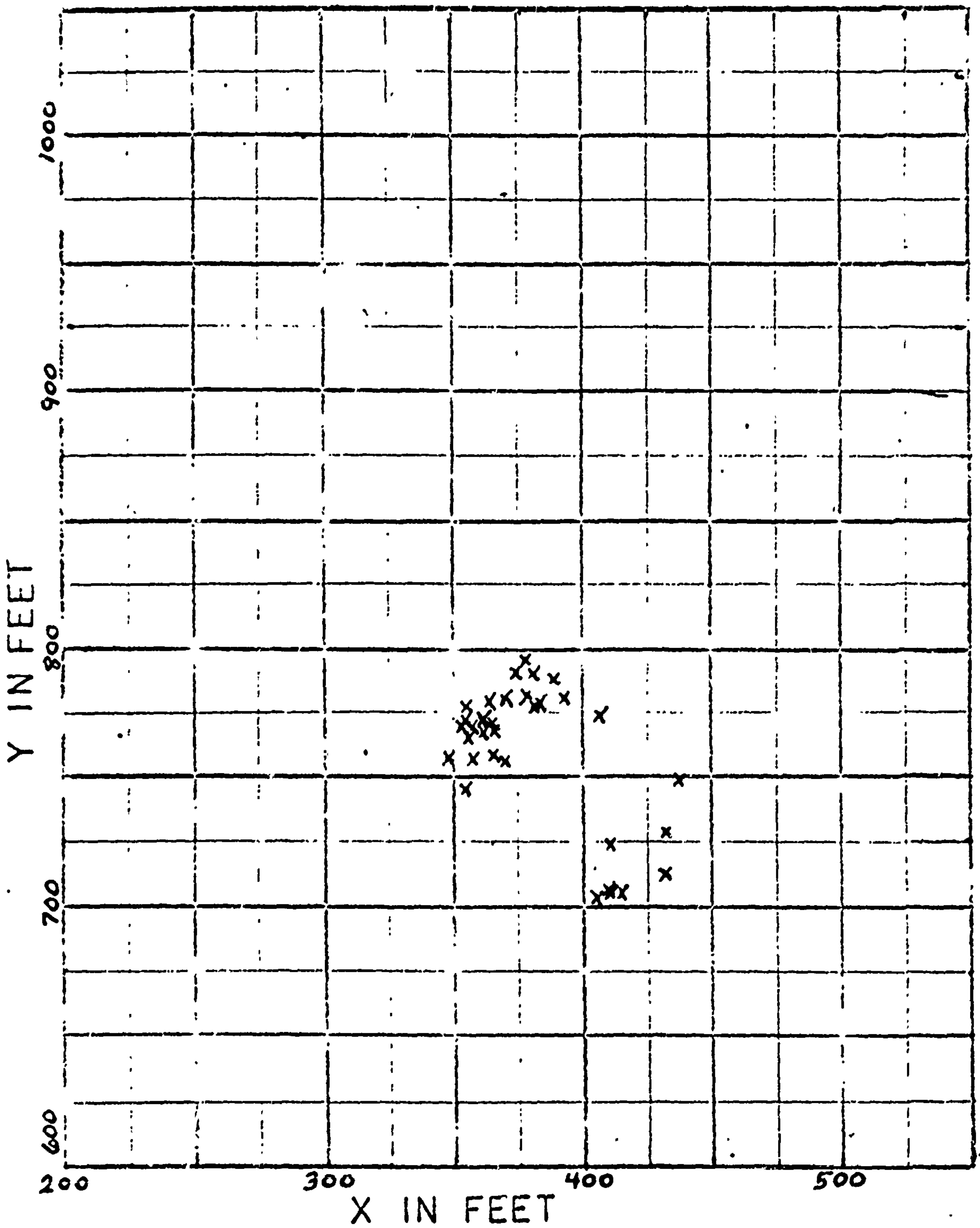

8-C39

CONFIDENTIAL

CONFIDENTIAL

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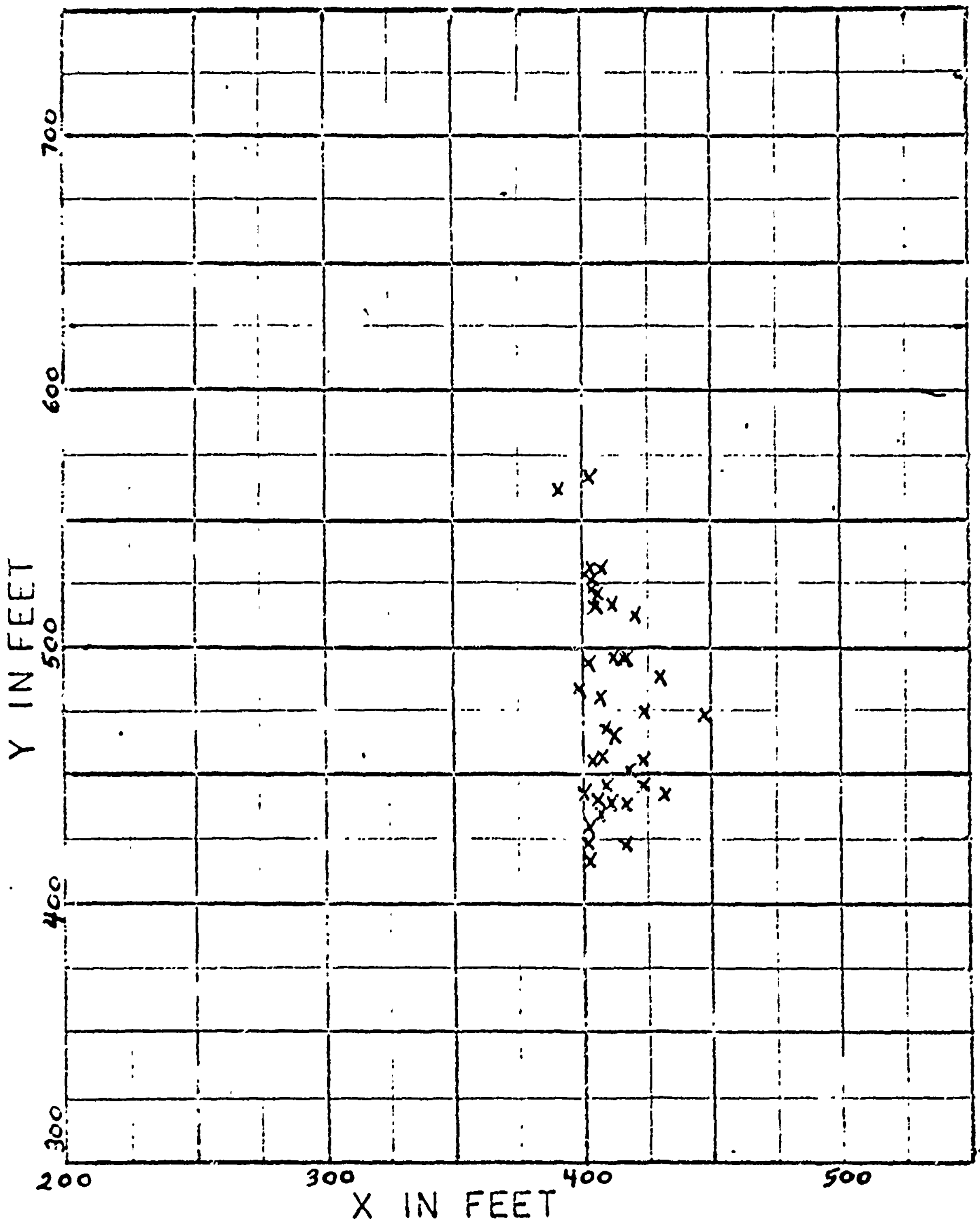

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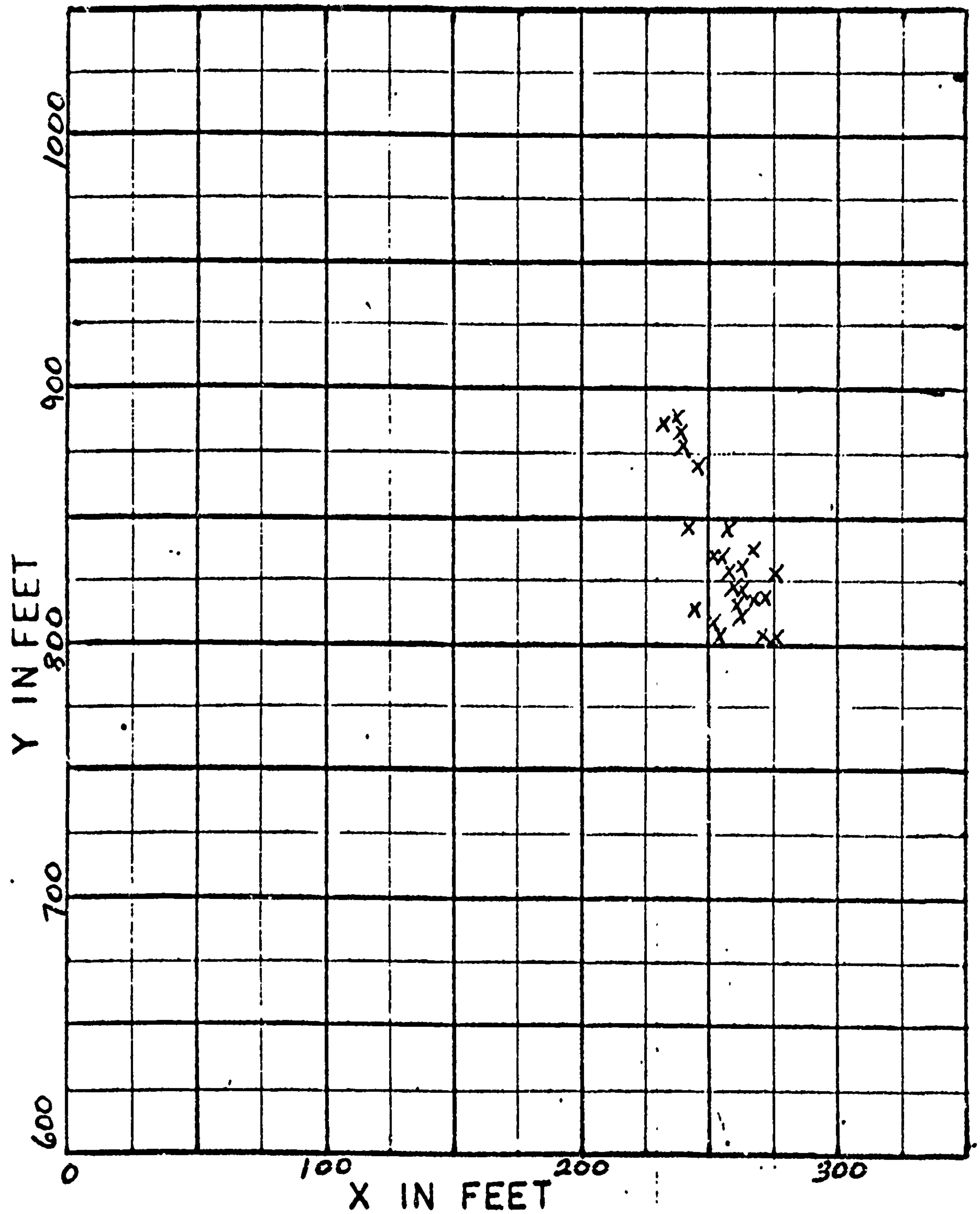

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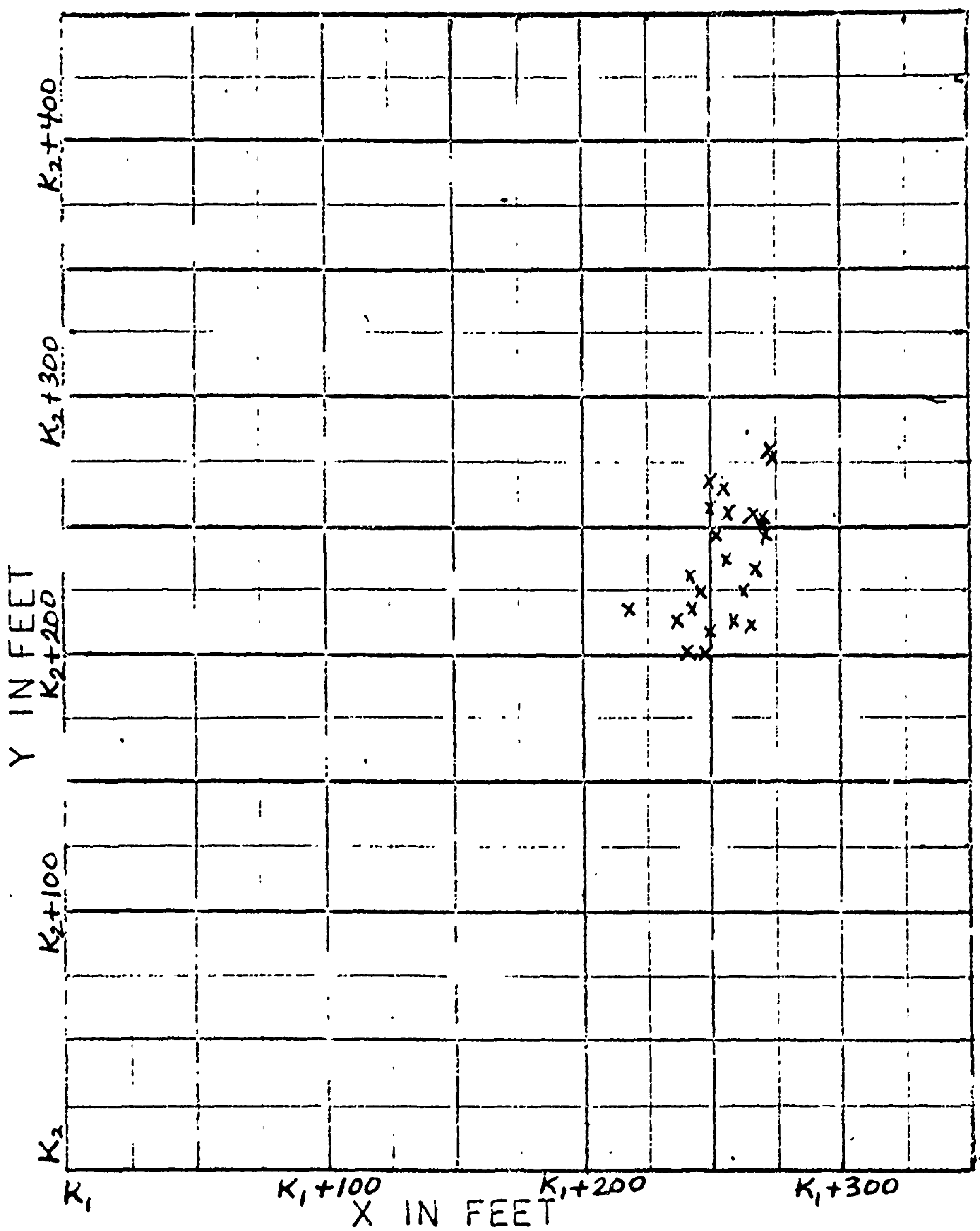

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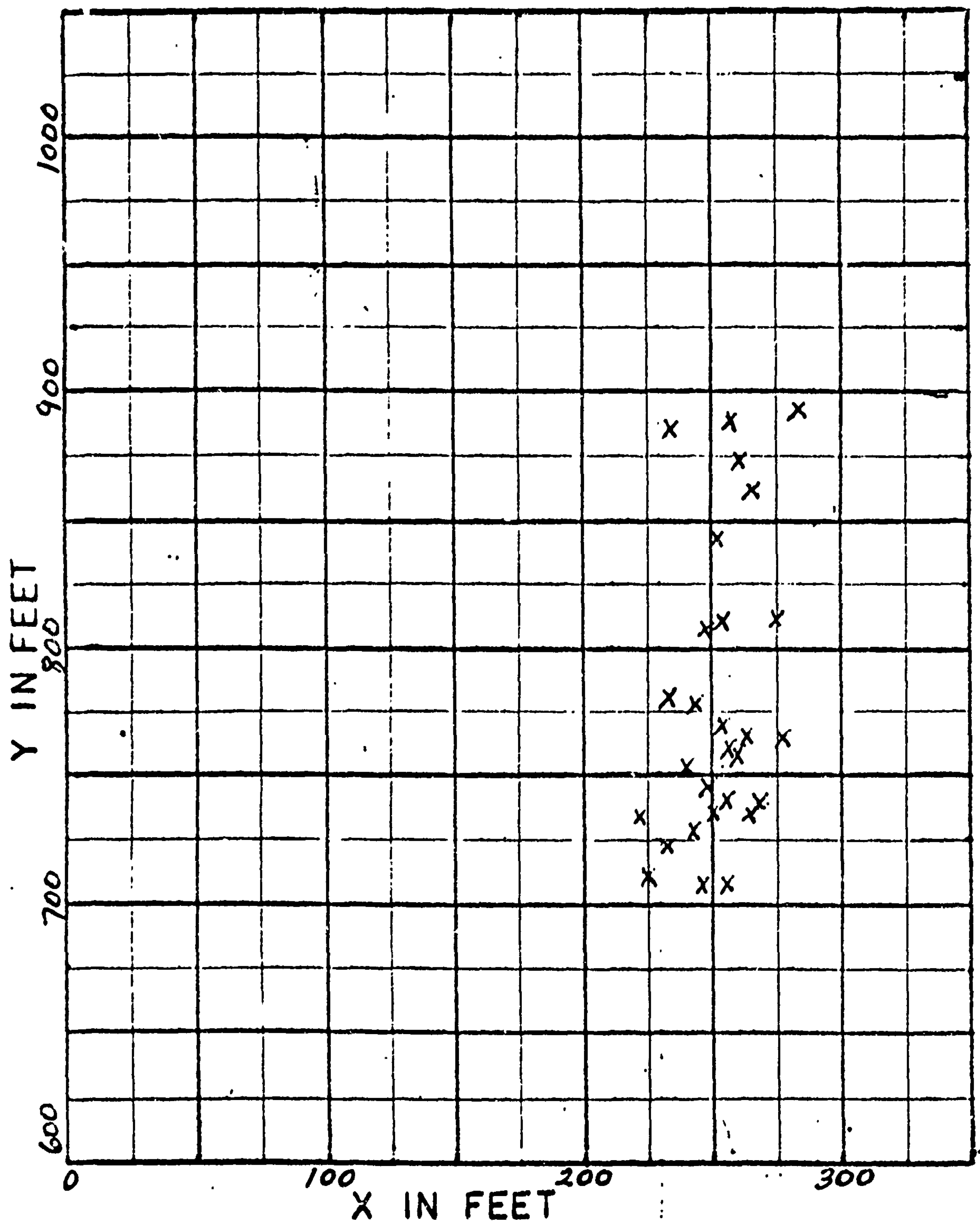

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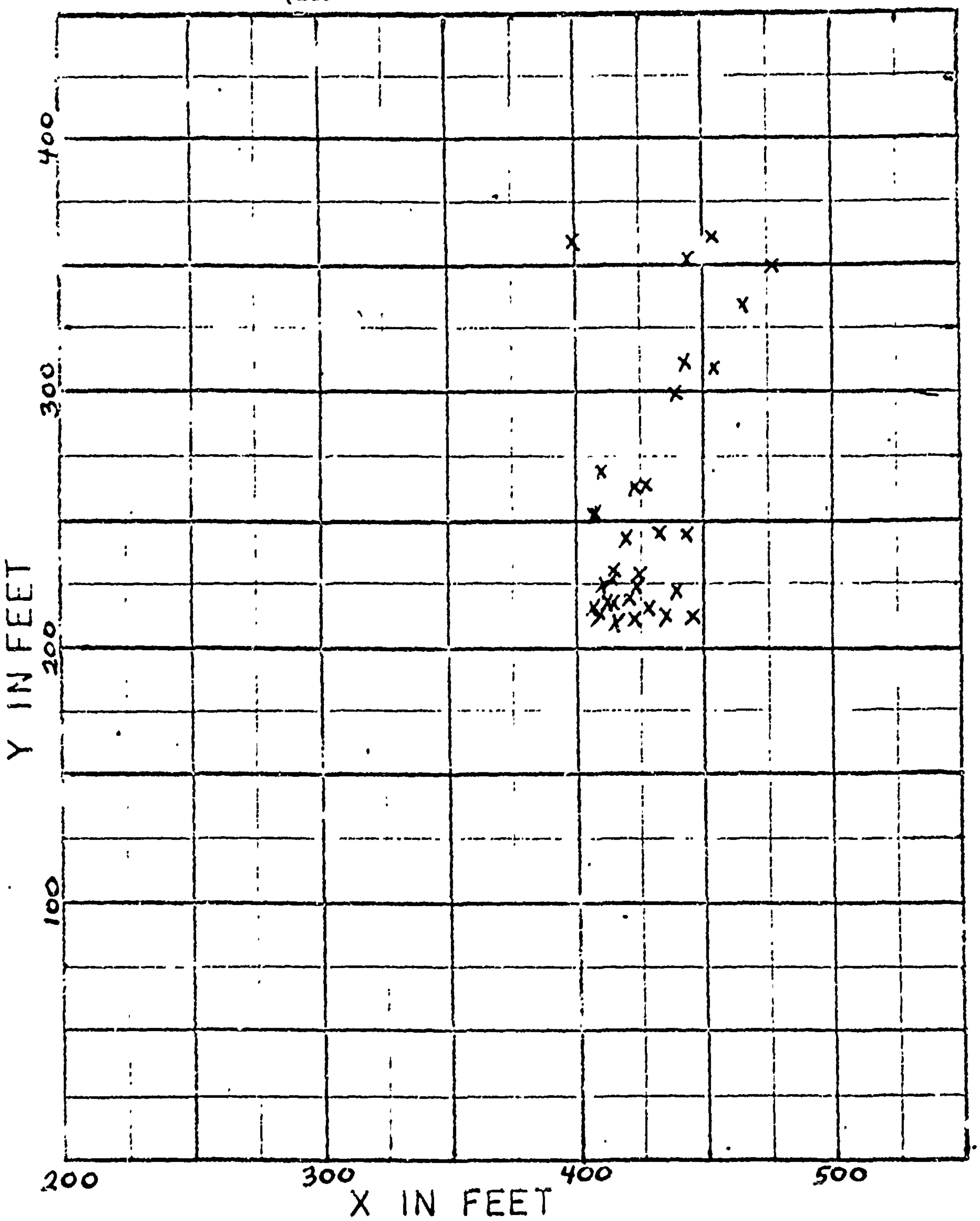

APPENDIX D

DEFINITIONS

1.0 INTRODUCTION

(U) This appendix contains the definitions used in the data presentation of the Bomblet Dispenser test results.

2.0 DEFINITIONS

(U) Altitude represents the helicopter altitude above ground level. Ground level is about 3,000 feet above sea level at the test site. Helicopter altitude is obtained from an on board barometric pressure gauge.

(U) Heading represents the direction of helicopter ground speed referenced to the grid lines. The South CBU grid lines run at 335 degrees true; the North CBU grid lines run at 347.5 degrees true. Helicopter heading was obtained by measuring the TV video vertical with respect to the grid lines and subtracting the pan angle.

(U) Depression angle represents the angle of mount tilt measured down from the horizontal plane. A 90° depression angle points the TV camera straight down.

(U) Pan angle represents the azimuth of the mount with respect to the helicopter yaw axis. A positive angle means the mount is turned to direct the TV camera to the right.

(U) Median impact point ($\bar{X}$, $\bar{Y}$) represents the median X and median Y in the impact point distribution for each run.

(U) Dispersion (S_x, S_y) represents a one sigma deviation from the median. Two-thirds of the impacts were within the values presented.

(U) The (X, Y) coordinate system is aligned with either the North or the South CBU grid, depending on which was used for the test.

North CBU Grid

The positive X axis is 78.5° clockwise from true north,
The positive Y axis is 347.5° clockwise from true north,
and the origin is at the reference target.

South CBU Grid

The positive X axis is 65° clockwise from true north,
The positive Y axis is 335° clockwise from true north,
and the origin is at the reference target.

i

9.0 NITE GAZELLE/GRENADE LAUNCHER WEAPON SYSTEM (U)

ABSTRACT

(C) The NITE GAZELLE/Grenade Launcher Weapon System was designed to fire against personnel and light materiel. The Grenade Launcher fires 40mm grenades at the rate of 420 rounds per minute.

(C) The system was tested against grid targets on Range 3 of Nellis AFB, Nevada from 10 February 1970 through 5 May 1970. Thirty-seven flight tests were conducted at airspeeds from hover to 60 knots and altitudes from 600 to 3.000 feet. Flight test firing at Nellis produced a standard deviation of 4.2 mils (68% probability of hitting within 4.2 mils) for the forty-two firing bursts evaluated for impact dispersion.

UNCLASSIFIED

Figure 1

NITE GAZELLE/Grenade Launcher Weapon System in Flight

UNCLASSIFIED

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LIST OF ILLUSTRATIONS

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the Grenade Launcher Weapon System on the remotely piloted NITE GAZELLE helicopter. This weapon system is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems.

(C) The ARPA/Advanced Sensors NITE GAZELLE remotely piloted helicopter, with appropriate day/night sensors and target kill weapons, was conceived as an interdiction system to counter enemy infiltration along the waterways and roads of Southeast Asia. The sensors were selected to give the helicopter a real time navigation, target acquisition and optical fire control capability under both daylight and low light level conditions of night.

(C) The weapon package of the NITE GAZELLE/Grenade Launcher Weapon System is designed to destroy river vessels, trucks and armored vehicles. The drone is a Navy-Gyrodyne QH-50D ASW-20 remotely piloted, auto-flight controlled helicopter, with the ground command and control elements of the system in a trailer van to accomplish the testing program.

(C) The NITE GAZELLE remotely piloted helicopter system in its Grenade Launcher configuration (Figure 1) can be remotely piloted to any point within a 60 nautical mile radius. Wide angle TV video transmitted to the control station permits visual search for enemy targets. Once the target is acquired the gunner, controlling the TV zoom lens, zooms in on the target. The TV video, with projected reticle, acts as a gun scope for accurate gun aiming. Up to 150 grenade rounds may be fired. The results are transmitted back to the control station via TV video for real time kill evaluation. Additionally, an on board 16 mm motion picture camera records on film a permanent record of the mission. On completion of the mission, the helicopter is remotely piloted back to its recovery base.

(C) The flight test program covered by this report was conducted at Nellis Air Force Base, Nevada, from 10 February 1970 through 5 May 1970. Grenades were launched against stationary CBU grid targets and against stationary trucks. Weapon accuracy was evaluated by computing the standard deviation of the impacts about the centroid of the impacts. Two weapon and sensor mounts were evaluated, the "Big U" and the M5 Twin Turret. A total of 40 flight tests were conducted during the test program.

2.0 RESULTS

2.1 Summary of Results

(C) The Grenade Launcher test program ran from 10 February 1970 through 5 May 1970. The weapon and sensor system was flight tested on two types of mounts, the "Big U" and the M5 Twin Turret. The results obtained using the "Big U" were far better than those using the M5 Twin Turret. In flight weapon accuracy attained with the "Big U" mount was 4.2 mils compared with 20 mils on the M5 Twin Turret. (The accuracies given represent a pooled one-sigma standard deviation about the centroid of the impacts for each firing burst). System reliability was greater on the "Big U" mount. Seventy-five percent of the M5 Twin Turret mount tests were aborted in flight due to system failure, whereas only twenty-eight percent of the "Big U" mount tests were aborted. Results of Grenade Launcher flight tests are summarized, by mount, in Table 1.

TABLE 1 (Title Unclassified
Table Confidential)
GRENADE LAUNCHER TEST RESULTS BY MOUNT

Mount	Number of firing bursts evaluated	Weapon Accuracy (mils)	No. of Flights	System failure (percent)
"Big U"	42	4.2	25	28%
M5 Twin Turret	10	20	12	75%

2.2 Discussion of Test Results

2.2.1 "Big U" Mount

(C) Twenty-five tests were conducted on the "Big U" mount between 10 February 1970 and 5 May 1970 at Nellis AFB, Nevada. Fifteen flights were in the hit distribution phase of testing and ten were in the firing demonstration phase. Detailed test information is contained in Appendix C.

(C) Hit distribution data were obtained on fifty-four firing bursts of eight test flights. Forty-two firing bursts, in which approximately 500 rounds were fired, were used to evaluate dispersion. The resultant standard deviation was 4.2 mils, which represents a 68% probability that a grenade will impact within 4.2 mils of the centroid of the impact pattern.

(C) The miss distances which were collected are relevant only in that they reflect the aimpoint corrections which should have been applied to compensate for gravity drop, helicopter velocity and altitude and mount depression and pan angles.

(C) Night firing demonstrations were accomplished using the ITT Low Light Level Television system as a sensor for target acquisition and fire control capability. Runs were made at 1,600 feet in altitude using at first distant flares and then an ECOM developed "Big Light" as sources of illumination. The target (truck) was acquired and fired upon on both runs. Only one successful night demonstration flight was completed.

(C) Day flight tests were conducted firing high explosive rounds at trucks. One truck exploded when a grenade ignited its gas tank. Other hits were recorded.

(C) Seven of the twenty-five tests were aborted in flight. The aborts were caused by a link separation in the ammunition belt (once), loss of "Big U" mount controls (twice), poor Low Light Level TV (once) and gun jam (three times).

2.2.2 M5 Twin Turret Mount

(C) Twelve flight tests were conducted on the M5 Twin Turret Mount between 4 March 1970 and 26 March 1970 at Nellis AFB, Nevada. Detailed test information is contained in Appendix C. Only two firing tests and one check flight were successful.

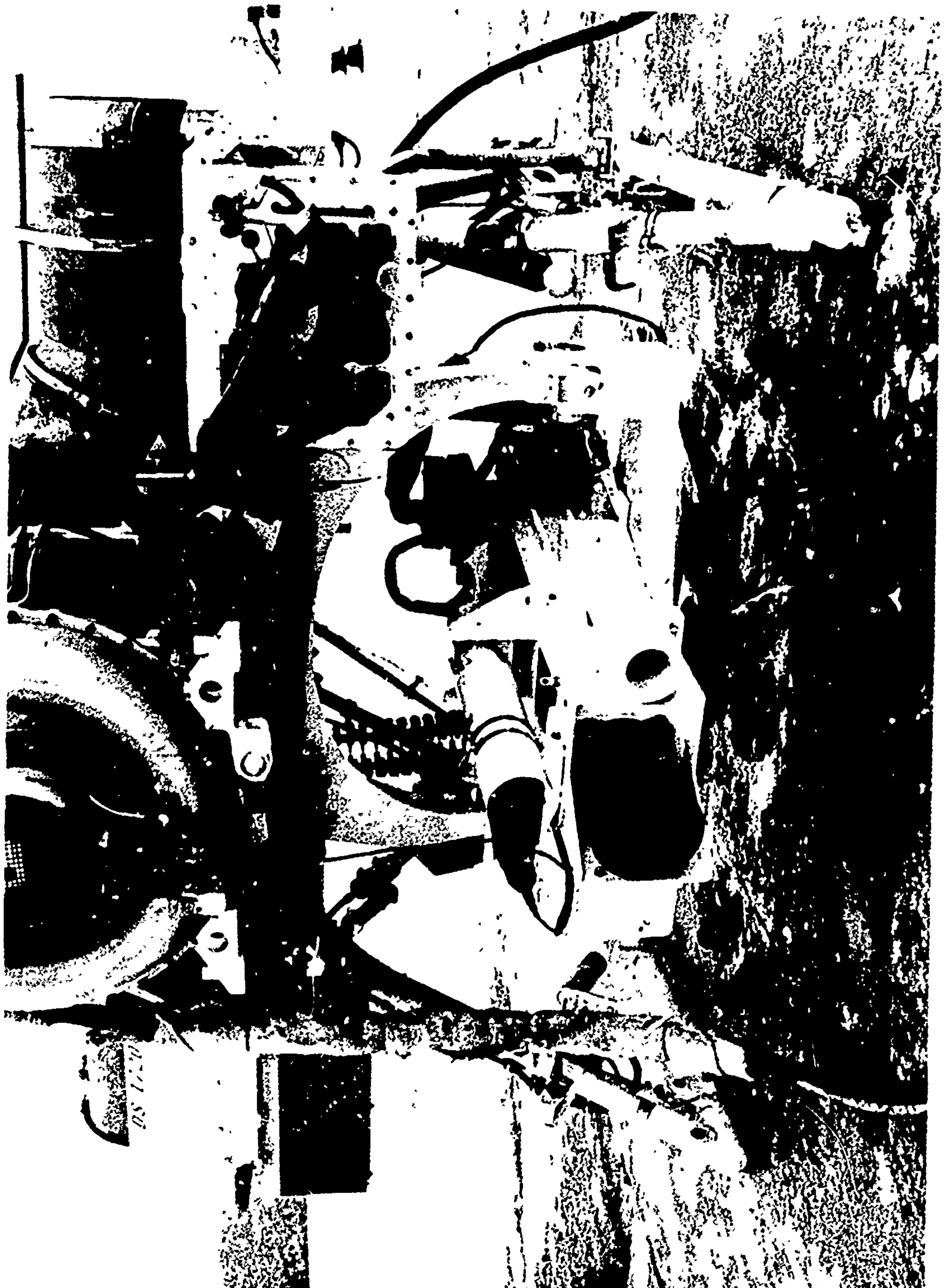
(C) Hit distribution data were obtained on two flight tests with nine firing tests being evaluated. The median dispersion was 2C mils.

(C) Mount control was notably worse than with the "Big U" mount according to the gun and mount controller, as recorded in the Test Conductor's Logs.

(C) Nine aborts were experienced due to poor TV, which occurred once, and a very persistent gun jamming problem, which occurred eight times. The gun jamming problem was attributed to excessive pressure in the ammunition feed chute.

3.0 SYSTEM DESCRIPTION

(C) The Grenade Launcher Weapon System consists of an XM-129 40 mm grenade launcher, which fires 420 rounds per minute, carried on a remotely piloted helicopter. The primary sensor for optical fire control of the weapon system is the day television system. A LLLTV was substituted on a limited number of night operations. The weapon and sensor were flight tested on two types of mounts, the "Big U", a rate commanded mount, and the M5 Twin Turret, a direction commanded mount. A complete description of the system is presented in Appendix A.



Close Up View of NITE GAZELLE/Grenade Launcher Weapon and Sensors Mount

Figure 2

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The NITE GAZELLE/Grenade Launcher Weapon System was tested at Nellis AFB, Nevada, between 10 February 1970 and 5 May 1970. The purpose of the testing was to determine system feasibility. Test program objectives were outlined as follows:

1) To evaluate the compatibility of the weapon system with the day/night on board sensors, and the use of these sensors as fire control devices.

2) To evaluate the capability of the system to recognize and acquire a specified target prior to a firing run.

3) To evaluate the hit distribution of the weapon system.

4) To assess the aiming error due to aircraft motion and due to the gunner's target tracking ability.

5) To assess inaccuracies from other sources.

4.2 Test Plan

(C) The NITE GAZELLE/Grenade Launcher Weapon System was tested on two mounts - the "Big U" mount and the M5 Twin Turret Mount. Testing of the weapon system on the "Big U" mount consisted of fifteen flights in the hit distribution phase of testing and ten flights of firing demonstrations in both day and night tests. Testing of the weapon system on the M5 Twin Turret mount consisted of twelve flights and did not proceed beyond the hit distribution phase.

(U) The hit distribution tests were conducted over the South CBU grid of Range 3. Ten wooden targets, 8' x 8' and 16' x 16', were placed at grid intersections and used for aimpoint references. Inert rounds of ammunition were marked so that the impact point of each numbered round could be physically measured for analysis of hit distribution.

(U) Firing demonstrations, which included both day and night test operations, launched high explosive grenades at unattended, stationary trucks.

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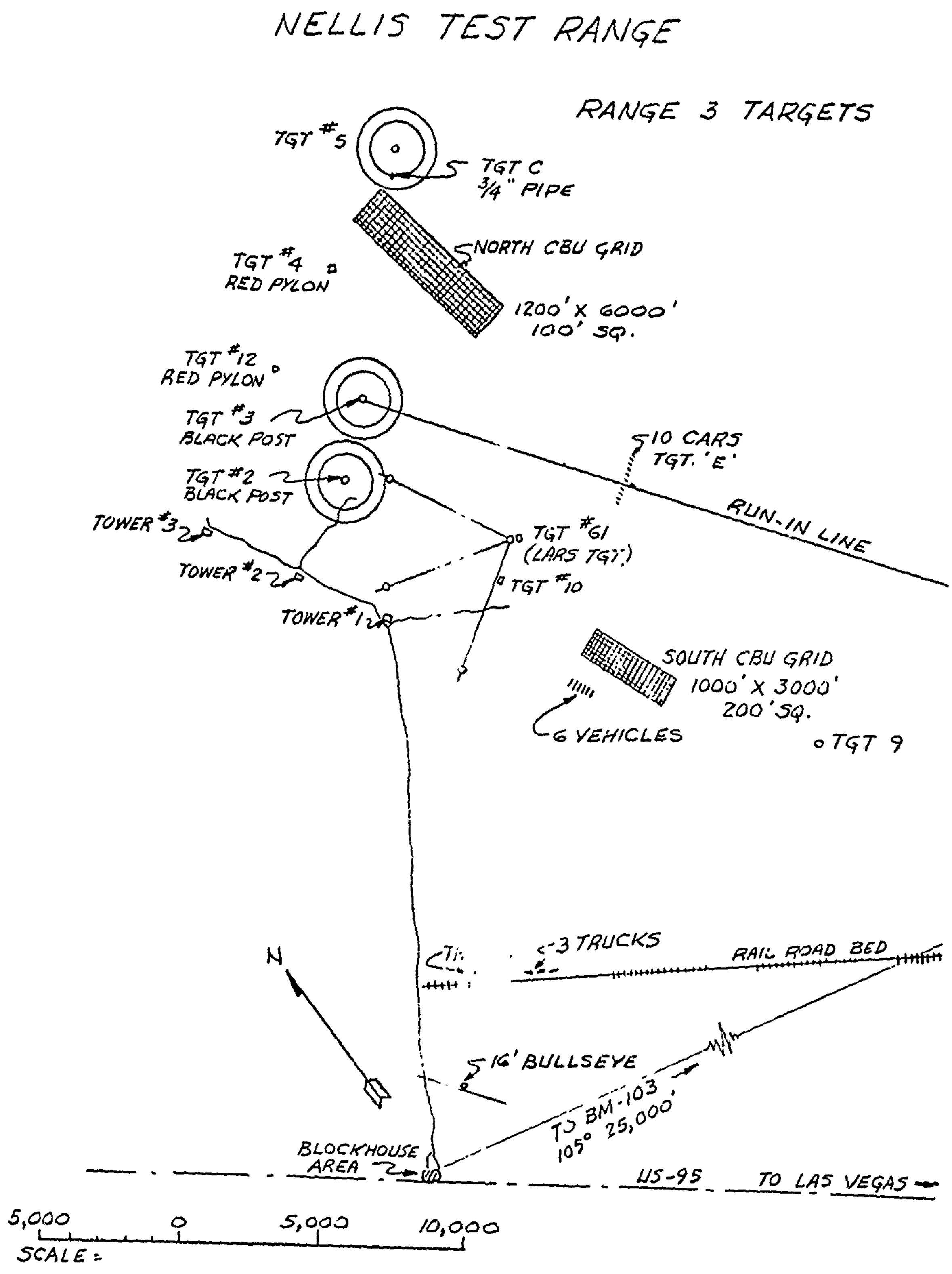

Figure 3

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5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the following areas:

Grenade Launcher
Helicopter
Data Link
Ground Station
Television
Tracking Mount

5.1 Grenade Launcher

5.1.1 Conclusions

(C) Nellis flight testing demonstrated that the XM-129 grenade launcher is compatible with the NITE GAZELLE delivery system and that the NITE GAZELLE/Grenade Launcher Weapon System offers excellent potential as a weapon system.

5.1.2 Recommendations

(U) None

5.2 Helicopter

5.2.1 Conclusions

(C) The helicopter proved to be a reliable vehicle during the test program.

5.2.2 Recommendations

(U) None

5.3 Data Link

5.3.1 Conclusions

(C) The data link performance for command data to the helicopter and response data from the helicopter was satisfactory.

5.3.2 Recommendations

(U) None

5.4 Ground Station

5.4.1 Conclusions

(C) The ground station proved to be effective for all aspects of the test program.

5.4.2 Recommendations

(U) None

5.5 Television

5.5.1 Conclusions

(C) The high resolution day television system provided satisfactory information for target location and identification.

(C) Night testing was too limited to draw any conclusions about the effectiveness of the ITT Low Light Level Television System for target acquisition and as a fire control device.

5.5.2 Recommendations

(U) None

5.6 Tracking Mount

5.6.1 Conclusions

(C) Flight test results demonstrated the "Big U" mount to be far superior to the M5 Twin Turret Mount. The "Big U" mount yielded better gun accuracy in flight and more system reliability.

5.6.2 Recommendations

(C) The "Big U" mount should be used in the NITE GAZELLE/Grenade Launcher Weapon System.

BIBLIOGRAPHY

1 "Big Eagle Hardware Summary (U)", Confidential Report, ARPA, August 1970.

2 "Armed Drone Feasibility Test (U)", Confidential Report, prepared by Roy Austil, Aircraft Weapons System Laboratory, U. S. Army Weapons Command Research and Engineering Directorate, Rock Island, Illinois, August 1970.

GLOSSARY

CBU	Cluster Bomb Unit
DAME	Distance and Azimuth Measuring Equipment
ECOM	Electronics Command
EOD	Explosive Ordnance Disposal
HE	High Explosive
ITT	International Telephone and Telegraph
LLLTV	Low Light Level Television
UHF	Ultra High Frequency
A/C	Aircraft

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(C) The system under test consisted of an XM-129 40mm grenade launcher. The grenades were launched from a remotely piloted helicopter.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE remotely piloted helicopter is a modified counter-rotating, double-bladed helicopter, which was originally developed by the U.S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horse-power gas turbine engine, yielding an 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius, with the Grenade Launcher configuration of weapon and sensors, is about 35 nautical miles with 30 minutes on station.

2.2 The Surveillance Tracking and Weapons Mount

2.2.1 "Big U" Mount

(U) The "Big U" is a rate commanded, inverted U-shaped, gyro-stabilized weapon/sensors mount. Weapon and sensors are mounted on a platform suspended between the two arms of the "Big U". The mount insulates weapon and sensors from extraneous vibrations.

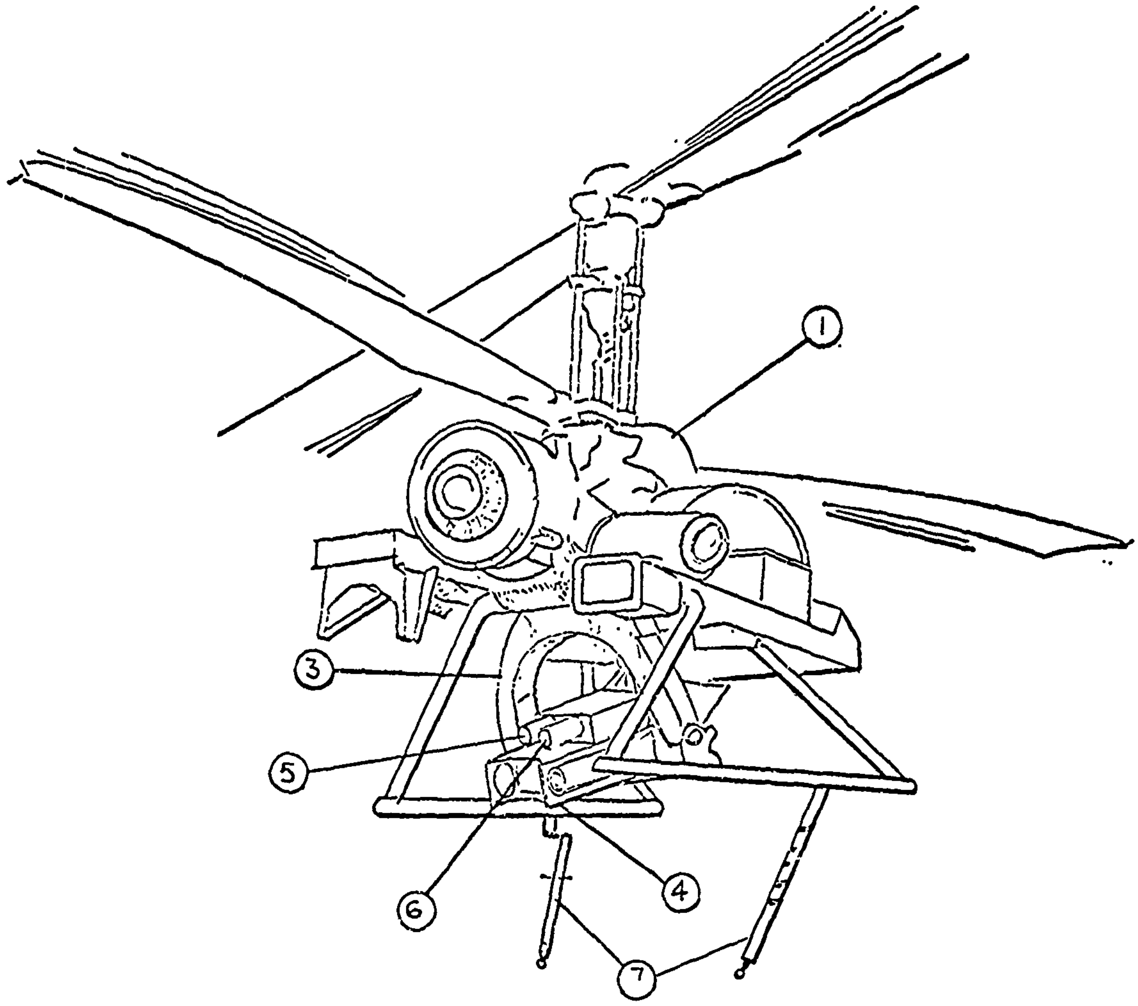
(U) The platform is remotely controlled in pan and tilt for target tracking and gun aiming. The "Big U" can be moved through a traverse angle of ±25° at a maximum pan rate of 2° per second. The platform can be depressed from the horizontal to -100° at a maximum tilt rate of 3° per second.

(U) The mount is centrally located under the drive shaft to provide maximum stability during in flight operations.

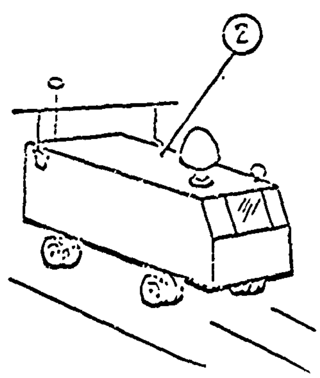
2.2.2 M5 Twin Turret Mount

(U) The M5 Twin Turret Mount, the standard mount used on the UH1 (Huey) helicopter, is fixed to the underside of the NITE GAZELLE. It houses the XM-129 40mm Grenade Launcher and the day television camera which is slaved to the grenade launcher.

(U) The weapon and the TV camera are remotely controlled in pan and tilt. Command signals from the ground controller's station repositions the direction of the mount with respect to the helicopter. The mechanical limits



NITE GAZELLE GRENADE LAUNCHER



1. HELICOPTER DRONE QH 50D (UNFAIRED)
2. NITE GAZELLE CONTROL VAN
3. SURVEILLANCE TRACKING AND WEAPON MOUNT, "BIG U"
4. GRENADE LAUNCHER
5. 16MM MOTION PICTURE CAMERA
6. DAY TELEVISION
7. ANTENNA

Figure A-1

are ±15 degrees in pan and 0 to -100 degrees depression from the horizontal.

(C) The design of the M5 Twin Turret Mount permits the transfer of aircraft motion to the weapon and TV camera.

(C) Mount movement is not smooth, as is the rate commanded "Big U", but rapid and jerky in comparison.

2.3 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and a fire control position for target acquisition and sensor and weapon control.

(U) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data are sent to the ground via an S-band link, and TV imagery is transmitted to the ground via an L-band link.

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He can operate the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communication relay system, permits operations beyond the ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

(U) The fire controller monitors the surveillance tracking and controls the weapon mount by viewing telemetered TV video. He controls the TV camera zoom lens, the 16 mm film camera, and transmits the firing signals.

2.4 The XM-129 40mm Grenade Launcher

(U) The XM-129 40mm Grenade Launcher fires at a nominal rate of 420 rounds per minute with an 8500 RPM motor. There is a 20:1 gear drive. The box dimensions of the gun are 9.06 inches wide, 9.14 inches high and 19.25 inches long which increases to 23.7 inches long when the barrel extends for ejecting spent cartridges and charging. Muzzle velocity is 800 ±20 feet per second. Peak recoil forces approach 2,400 pounds.

2.5 Day Television System

(U) The Day Television Camera is used as the primary sensor on the NITE GAZELLE/Grenade Launcher Weapon System. The camera is manufactured by COHU Electronics Corporation. This cylindrical unit is 4 inches in diameter, 19 inches long and weighs 27 pounds. Resolution is 945 lines at

one footcandle illumination on the face plate.

(U) The camera lens is a 30 mm to 300 mm zoom with a 2X extender changing focal length and zoom to 60 mm to 600 mm, f4 to f48, covering a field of view of 23 degrees down to 2.3 degrees at full zoom. The zoom and f-stop are remotely controlled from the fire controller's station on the ground. The lens system includes a fixed reticle which is remotely illuminated and extinguished.

(U) The TV transmission bandwidth is 20 MHz, with a power requirement of 45 watts.

2.6 The Low Light Level Television System (LLLTV)

(U) The Low Light Level Television System replaces the Day Television System for target identification and optical fire control during night operations. The LLLTV selected was an ITT model with a plumbicon image tube and three PIP-25 intensifiers in cascade. The system consists of a camera head, a camera control unit and a ground based TV monitor. The camera head, which houses the lens system, is 25" long, 6" in diameter and weighs 38 pounds. The camera control unit is 5" x 10", weighs 12 pounds and has a peak power requirement of 44 watts. The f1.5 zoom lens has a 57.5 to 230 mm focal length and a corresponding change in field of view from 16.8 to 4.2 degrees. The system provides a resolution of 575 TV lines on clear, full moon nights at 3×10^{-5} footcandles on the face plate.

2.7 16 MM Motion Picture Camera

(U) The 16 mm Motion Picture Camera is co-mounted beside the TV camera to provide a clear visual sensor and a historic record of areas of interest.

(U) The camera is manufactured by Photosonics and operates at a frame rate of 24 to 200 frames per second. It is fitted with a 25 mm to 250 mm zoom lens with a normal aperture of f2.8-22. The focal length is remotely controlled in flight to provide the proper magnification and field of view to document the mission. The on board exposure control unit is automatic.

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 and Table B-2 present a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR GRENADE LAUNCHER "BIG U" MOUNT OPERATIONS

Date	Test No.	Plan	Comments
2/10/70	12	Boresight	Good to 2 mils
2/11/70	1	Check Flight	No adverse effects on A/C during firings.
2/12/70	1	Impact Scoring	Four firing runs. Some HE rounds did not explode.
2/12/70	1	Impact Scoring	Four firing runs. Forty-four inert rounds fired and scored.
2/13/70	1	Impact Scoring	Seven firing runs. Five HE rounds fired. 100 inert rounds fired and scored.
2/16/70	2	Impact Scoring	Aborted in flight. Link separation in ammunition belt.
2/16/70	2	Impact Scoring	Aborted in flight. Empty casing backwards in firing chamber.
2/17/70	5	Impact Scoring	Six firing runs. 91 inert rounds fired and scored.
2/18/70	6	Impact Scoring	Aborted in flight. Loss of "Big U" mount controls.
2/18/70	6	Impact Scoring	Four firing runs. 56 inert rounds fired and scored.
2/19/70	8	Impact Scoring	Six firing runs. 44 inert rounds fired and scored.

Table B-1 Continued

Date	Test No.	Plan	Comments
2/19/70	9	Impact Scoring	Six firing runs. 90 inert rounds were fired and scored.
2/20/70	4	Impact Scoring	Seven firing runs. 61 inert rounds were fired and scored.
2/26/70	7	Strafing	Five strafing runs.
2/26/70	10	Strafing	Two strafing runs. 130 inert rounds fired and plotted.
2/26/70	11	Impact Scoring and Strafing	Five firing runs. Strafing run not scored. 48 inert rounds were fired and scored in remaining four runs.
4/1/70	-	Check Flight	Preparation for night demonstration.
4/1/70	40	Night Demo.	Aborted in flight due to poor LLLTV performance.
4/3/70	41	Firing Demo.	Two firing runs of HE rounds against stationary truck.
4/19/70	40B	Dress Rehearsal for Night Demo.	Two firing runs. Lift-off at 1434 local time. Touch down at 1523.
4/23/70	40	Night Firing Demo.	Two firing runs. ECOM Big Light and flares source of illumination.
4/23/70	40A	Night Firing	Aborted in flight due to failure of the gun to fire.
4/23/70	41	Firing Demo.	Aborted in flight due to broken link in ammo. belt.
4/24/70	41	Firing Demo.	Three firing runs. HE rounds against stationary trucks.
4/30/70	42	Firing Demo.	Aborted in flight. No mount control - pitch axis motor defective.
5/5/70	42	Firing Demo.	Three firing runs. HE rounds against stationary trucks.

TABLE B-2 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR GRENADE LAUNCHER TWIN TURRET MOUNT OPERATIONS

Date	Test No.	Plan	Comments
3/4/70	-	Check Flight	All systems functioned properly.
3/5/70	1A	Impact Scoring	Aborted in flight. Loss of TV signal.
3/5/70	1A & 3	Impact Scoring	Aborted in flight. Gun jammed after first round.
3/18/70	12A	Boresight	Calibration burst verified accurate boresighting.
3/20/70	1A & 2A	Impact Scoring	Aborted in flight. Gun jammed after first round.
3/23/70	1A	Impact Scoring	Aborted in flight. Gun jammed.
3/23/70	1A	Impact Scoring	Aborted in flight. Sheared pin in gun mechanism.
3/23/70	1A	Impact Scoring	Aborted in flight. Gun jammed after first round.
3/24/70	-	Diagnostic Test	Two firing runs over lake bed. 45° depression angle.
3/25/70	1A & 2A	Impact Scoring	Nine firing runs. 98 inert rounds fired and scored.
3/25/70	8A & 9A	Impact Scoring	Aborted in flight. Gun jammed.
3/26/70	3A	Impact Scoring	Three firing runs. First two bursts were scored.
3/26/70	3A	Impact Scoring	Aborted in flight. Gun jammed.

APPENDIX C

FLIGHT TEST DATA FOR GRENADE LAUNCHER

(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

SECTION C-1
"BIG U" MOUNT

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 12
10 February 1970

(U) This test was conducted to confirm proper alignment between the XM-129 grenade launcher and the TV reticle, which is used for gun aiming. The XM-129 grenade launcher had been parallel boresighted (collimated) with the TV camera. The grenade launcher centerline is located 1 inch right of and 7.5 inches below the TV reticle, therefore at close ranges grenade launcher round impacts should occur 1 inch right of and 7.5 inches below the TV aimpoint.

(U) The boresighting calibration check was performed by firing three ten-round bursts at a boresighting target 1,000 inches from the grenade launcher, as it was mounted on the "Big U" mount of the helicopter. The helicopter was resting on the pad with rotors turning and power on.

(U) The centroid of the impact pattern for each firing burst was measured and recorded. The dispersion of the impacts was not measure.

(C) The centroid of the impacts with respect to the aimpoint was recorded as follows for each burst.

	Centroid	
1st burst	1.5" right	3.5" down
2nd burst	2.0" right	6.0" down
3rd burst	2.0" right	7.0" down

The average of the three centroids is 1.8" right and 5.5" down which is about 2 mils above the theoretical impact point (1.5" right, 7.5" down). This was within the desired boresighting accuracy.

CHECK FLIGHT
Flight No. 1 Test No. 1
11 February 1970

(C) This test was a check flight to determine the effect of Grenade Launcher

firing on helicopter stability. Six one-second bursts were fired at an altitude of 600 feet and a ground speed of 30 knots. No adverse effects on the aircraft were observed during the firings. Flight duration was sixty-six minutes.

HIT DISTRIBUTION TEST
Flight No. 2 Test No. 1
12 February 1970

(C) This test consisted of four firing runs at South CBU grid targets for the purpose of collecting hit distribution data. Twenty-one rounds of high explosive (HE) ammunition and twenty-one rounds of inert ammunition were fired. Nine of the twenty-one HE rounds did not explode making the target area inaccessible to the scoring team. The area was cleared by EOD personnel. Flight duration was thirty-five minutes.

HIT DISTRIBUTION TEST
Flight No. 3 Test No. 1
12 February 1970

(C) This test consisted of four firing runs at South CBU grid targets for the purpose of collecting hit distribution data. Forty-four inert rounds were fired in bursts of 12, 15, 5 and 12. Dispersion of impacts was 6.8, 4.2, 12.9 and 3.2 mils. Grid targets were used for aiming only. No aimpoint offsets were applied to correct for gravity drop, drone airspeed and altitude. Flight duration was sixty minutes.

Weather Conditions

Barometric Pressure: 26.78" Hg
Temperature: 66°F
Wind, Surface: 5 to 20 knots from 120° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	-20°	90°	0°
2	30	600	+ 0°	45°	0°
3	30	600	-20°	90°	-15°
4	30	600	+ 5°	45°	-15°

SOUTH CBU GRID
RANGE 3, NELLIS AFB, NEVADA

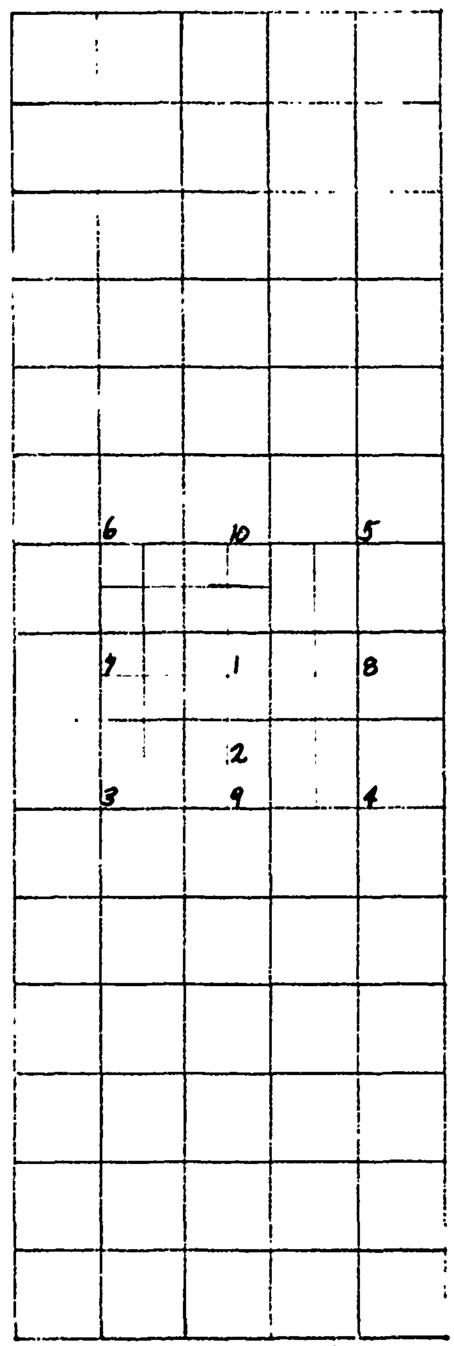


Figure C1

THE SOUTH CBU GRID IS 3000' X 1000'. EACH SQUARE REPRESENTS 200', EXCEPT IN THE GRID CENTER WHICH IS SUBDIVIDED INTO 100' SQUARES.

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Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	12	1.5	3.8	4.1	6.8
2	15	2.5	2.3	3.4	4.2
3	5	1.2	7.6	7.7	12.9
4	12	1.5	2.3	2.7	3.2

Impact Coordinates (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	15.2	61.9	7	17.3	65.5
2	16.3	62.5	8	13.7	67.3
3	14.0	63.0	9	14.0	68.3
4	14.8	63.7	10	14.2	68.7
5	12.8	65.0	11	16.2	71.4
6	13.3	65.9	12	16.9	74.8

Aimpoint: (target 2) X = 7.0 feet, Y = 2.4 feet

Centroid: (of impacts) $\overline{X}$ = +14.9 feet, $\overline{Y}$ = +66.5 feet

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	7.5	61.8	9	2.7	66.0
2	7.0	62.0	10	4.3	66.2
3	8.3	62.7	11	4.5	66.9
4	8.4	63.8	12	5.0	67.4
5	10.8	63.5	13	4.4	67.8
6	7.2	65.5	14	2.4	68.9
7	9.0	65.5	15	4.3	69.1
8	4.2	65.5			

Aimpoint: (target 1) X = +4.6 feet, Y = -4.2 feet

Centroid: (of impacts) $\overline{X}$ = + 6.0 feet, $\overline{Y}$ = +65.5 feet

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Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-25.3	58.4
2	-25.5	59.0
3	-26.0	62.9
4	-27.7	68.3
5	-24.6	73.8

Aimpoint: X = +6.7 feet
(target 2) Y = -7.1 feet

Centroid: $\overline{X}$ = -25.8 feet
(of impacts) $\overline{Y}$ = +65.1 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-8.3	61.8
2	-6.8	63.0
3	-11.2	63.2
4	-8.7	63.4
5	-9.6	64.2
6	-10.3	65.0
7	-11.2	66.1
8	- 8.0	66.7
9	- 7.3	67.3
10	- 9.3	67.8
11	- 8.0	67.9
12	-10.4	68.7

Aimpoint: X = 8.3 feet
(target 1) Y = -9.2 feet

Centroid: $\overline{X}$ = -9.1 feet
(of impacts) $\overline{Y}$ = +65.4 feet

HIT DISTRIBUTION TEST
Flight No. 4 Test No. 1
13 February 1970

(C) This test consisted of one run using high explosive ammunition and six runs using inert ammunition. The test was conducted over the South CBU grid for the purpose of gathering hit distribution data. Five rounds of HE ammunition and one hundred rounds of inert ammunition were fired in bursts of 5, 3, 4, 3, 5, 12 and 73. Dispersion of impacts, computed on inert firings was 4.8, 4.8, 2.5, 2.1, 4.4 and 4.6 mils. Grid targets were used for aiming only. No corrections were applied to the grenade trajectories in order to hit the targets.

(C) The long firing burst in Run No. 7 was chosen to evaluate mount jitter as it affects the gunner's ability to hold the aimpoint on target during a firing burst. The aimpoint was measured on each of two hundred frames of mount camera film spanning eight seconds of the firing interval. The standard deviation of the aimpoints was computed in both the lateral and vertical axes. The standard deviation was 1.7 mils in azimuth and 2.7 mils in elevation. It was noted that during the long firing burst of Run No. 7, the drone pitched nose down two degrees.

Weather Conditions

Barometric Pressure: 26.68" Hg
Temperature: 58°F
Wind, Surface: 4 knots from 270° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
2	30	1000	+40°	85°	+12°
3	30	1000	+45°	85°	- 7°
4	30	1000	+10°	45°	- 5°
5	30	1000	+15°	43°	- 4°
6	30	1000	+15°	85°	+ 5°
7	30	1000	- 5°	43°	+ 3°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
2	3	1.2	4.6	4.8	4.8
3	4	1.1	4.7	4.8	4.8
4	3	1.2	3.3	3.5	2.5
5	5	2.2	2.1	3.1	2.1
6	12	1.7	4.1	4.4	4.4
7	73	3.1	6.0	6.7	4.6

Impact Coordinates (Title Unclassified)

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	27.3	81.3
2	26.0	74.2
3	28.4	72.6

Round No.	Impact Point X (feet)	Impact Point Y (feet)

Aimpoint: (target 2) X = +6.4 feet, Y = -3.7 feet

Centroid: (of impacts) $\overline{X}$ = +27.2 feet, $\overline{Y}$ = +76.0 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	62.8	81.9
2	60.3	73.1

Round No.	Impact Point X (feet)	Impact Point Y (feet)
3	62.3	75.5
4	61.0	71.2

Aimpoint: (target 3) X = +3.2 feet, Y = +1.4 feet

Centroid: (of impacts) $\overline{X}$ = +61.6 feet, $\overline{Y}$ = +75.4 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	31.4	66.2
2	31.3	62.3
3	33.4	68.8

Aimpoint: (target 1) X = +2.5 feet, Y = +6.4 feet

Centroid: (of impacts) $\overline{X}$ = +32.0 feet, $\overline{Y}$ = +65.8 feet

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Run No. 5 (Table Confidential)

	Impact Point			Impact Point	
Round No.	X (feet)	Y (feet)	Round No.	X (feet)	Y (feet)
1	31.0	61.3	4	34.5	58.8
2	34.0	56.0	5	36.4	57.5
3	36.5	56.7			

Aimpoint: (target 1) X = +3.3 feet, Y = +1.8 feet

Centroid: (of impacts) $\bar{X}$ = +34.5 feet, $\bar{Y}$ = +58.1 feet

Run No. 6 (Table Confidential)

	Impact Point			Impact Point	
Round No.	X (feet)	Y (feet)	Round No.	X (feet)	Y (feet)
1	22.3	88.6	7	23.6	93.8
2	21.5	86.4	8	26.5	92.2
3	22.6	88.3	9	24.7	91.0
4	24.2	88.2	10	25.0	96.6
5	21.6	91.5	11	25.7	100.0
6	25.3	91.9	12	25.0	96.6

Aimpoint: (target 3) X = +6.9 feet, Y = +1.1 feet

Centroid: (of impacts) $\bar{X}$ = +24.0 feet, $\bar{Y}$ = +92.1 feet

Run No. 7 (Table Confidential)

	Impact Point			Impact Point	
Round No.	X (feet)	Y (feet)	Round No.	X (feet)	Y (feet)
1	10.3	56.5	6	13.3	62.3
2	11.6	57.0	7	14.1	62.6
3	10.7	60.3	8	12.2	64.3
4	8.3	59.9	9	10.9	62.9
5	8.1	62.7	10	10.0	69.3

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Run No. 7 (cont) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
11	9.0	66.5	42	7.1	71.3
12	9.3	62.4	43	6.7	71.0
13	10.7	61.3	44	7.2	71.5
14	9.0	64.8	45	7.0	72.3
15	9.4	68.1	46	7.5	72.0
16	9.1	69.5	47	6.4	72.3
17	6.3	74.3	48	3.2	72.5
18	7.6	76.4	49	3.5	71.2
19	3.7	78.9	50	5.0	71.2
20	1.6	77.5	51	7.0	71.3
21	4.7	77.8	52	2.7	71.6
22	2.6	79.6	53	2.5	74.3
23	3.0	74.5	54	3.3	75.5
24	-1.0	73.0	55	2.7	73.2
25	2.7	74.5	56	1.2	76.2
26	3.7	73.8	57	2.3	76.7
27	6.7	72.2	58	1.8	76.7
28	6.0	73.6	59	3.2	77.1
29	6.2	76.0	60	2.2	78.7
30	4.2	71.3	61	5.8	78.8
31	3.8	70.9	62	5.3	78.9
32	2.7	70.7	63	4.8	80.0
33	6.4	72.3	64	3.2	80.6
34	7.3	72.0	65	4.4	80.6
35	6.9	71.8	66	7.2	80.5
36	6.4	70.5	67	5.7	80.3
37	5.8	66.3	68	7.3	81.6
38	10.6	72.0	69	8.2	77.7
39	6.6	67.4	70	7.9	76.8
40	8.4	67.0	71	7.7	75.3
41	7.7	71.0	72	9.5	71.1
			73	9.7	70.8

Aimpoint: (target 1) $X = +5.9$ feet, $Y = +1.0$ feet

Centroid: (of impacts) $\overline{X} = +6.4$ feet, $\overline{Y} = +71.9$ feet

HIT DISTRIBUTION TEST
Flight No. 5 Test No. 2
16 February 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution data. The test was aborted in flight with only seven rounds fired. Post-test investigation revealed a link separation in the ammunition belt. No impact data were collected. Flight duration was forty-eight minutes.

HIT DISTRIBUTION TEST
Flight No. 6 Test No. 2
16 February 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution data. The test was aborted in flight after two firing runs with no observed firings. A post-test investigation revealed an empty casing found backwards in the firing chamber which was blocking the next round. Low tension spring steel fingers on the discharge chute were installed to preclude recurrence. No impact data were obtained on this test. Flight duration was forty-two minutes.

HIT DISTRIBUTION TEST
Flight No. 8 Test No. 5
17 February 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution data. Ninety-one inert rounds were fired in bursts of 7, 7, 8, 6, 28 and 35 rounds. Dispersion of impacts was 4.1, 4.1, 4.3, 2.7, 13.8 and 5.3 mils. The high dispersion in Run No. 5 (13.8 mils) was due to the gun controller raising the mount prior to completion of firing. This was determined from reviewing TV video. Flight duration was thirty-nine minutes.

Weather Conditions

Barometric pressure: 26.66" Hg
Temperature: 64°F
Wind: 10 knots to 18 knots from 330°T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	1500	+5°	83°	-2°
2	30	1500	0°	43°	-4°
3	30	1500	+15°	82°	-11°
4	30	1500	0°	43°	-15°
5	30	1500	--	85°	-2°
6	30	1500	0°	43°	+2°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	7	4.1	4.6	6.2	4.1
2	7	3.4	8.4	9.0	4.1
3	8	2.0	3.1	3.8	4.3
4	6	2.9	5.1	5.9	2.7
5	28	3.9	20.4	20.8	13.8
6	35	4.8	10.7	11.7	5.3

Impact Coordinates (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	39.6	93.6	5	39.0	78.2
2	40.8	87.3	6	36.3	85.5
3	42.6	86.9	7	29.8	83.3
4	38.4	86.2			

Aimpoint: (target 2) X = +5.5 feet, Y = -9.7 feet

Centroid: (of impacts) $\bar{X}$ = +38.1 feet, $\bar{Y}$ = +85.9 feet

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	66.9	-12.4
2	60.0	-6.7
3	62.7	-2.7
4	62.0	3.5

Aimpoint: X = +.9 feet
(target 1) Y = +2.9 feet

Round No.	Impact Point X (feet)	Impact Point Y (feet)
5	63.7	2.6
6	60.2	7.2
7	56.2	12.2

Centroid: $\bar{X}$ = +61.7 feet
(of impacts) $\bar{Y}$ = +.5 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	58.1	96.3
2	56.0	92.2
3	61.5	94.5
4	61.3	88.6

Aimpoint: X = +1.1 feet
(target 2) Y = +5.3 feet

Round No.	Impact Point X (feet)	Impact Point Y (feet)
5	57.5	97.2
6	59.5	95.4
7	61.3	93.7
8	60.2	98.7

Centroid: $\bar{X}$ = +59.4 feet
(of impacts) $\bar{Y}$ = +94.6 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	68.4	-.9
2	68.8	3.6
3	73.6	8.5

Aimpoint: X = +8.9 feet
(target 1) Y = +3.3 feet

Round No.	Impact Point X (feet)	Impact Point Y (feet)
4	66.4	7.2
5	68.3	14.3
6	73.3	7.0

Centroid: $\bar{X}$ = +69.8 feet
(of impacts) $\bar{Y}$ = +6.6 feet

Run No. 5 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	10.0	16.5	15	3.6	34.6
2	3.7	13.1	16	3.2	39.1
3	9.3	10.5	17	-1.7	41.2
4	2.7	17.3	18	0	50.9
5	3.4	15.8	19	-1.2	53.7
6	5.4	17.3	20	0	55.5
7	4.5	19.5	21	-.3	60.1
8	4.7	17.7	22	-4.5	57.5
9	6.7	21.3	23	-1.6	62.3
10	0.4	25.2	24	-4.4	64.4
11	5.7	28.9	25	-1.6	68.7
12	2.3	31.5	26	-3.0	66.6
13	5.0	34.2	27	0	70.7
14	1.7	36.0	28	-4.0	70.2

Aimpoint:
(100 feet short of target 2)

Centroid: $\overline{X}$ = +1.8 feet
(of impacts) $\overline{Y}$ = +39.3 feet

Run No. 6 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	7.0	22.6	15	15.8	33.6
2	1.2	31.9	16	14.2	37.3
3	5.2	27.6	17	17.0	50.8
4	4.1	28.2	18	17.0	57.8
5	3.7	38.6	19	19.0	53.4
6	5.1	38.6	20	14.4	54.6
7	7.9	33.1	21	18.2	52.2
8	7.7	27.2	22	8.2	44.6
9	9.2	34.2	23	15.5	47.2
10	5.1	35.1	24	11.7	51.6
11	6.7	40.2	25	15.7	54.8
12	9.8	32.2	26	16.7	53.1
13	7.4	29.7	27	15.7	60.2
14	10.5	34.7	28	13.2	59.5

Run No. 6 (cont) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
29	12.3	51.1	33	12.3	45.9
30	17.6	57.0	34	10.7	46.6
31	13.2	48.8	35	10.7	38.2
32	14.2	48.0			

Aimpoint: X = -2.8 feet
(target 1) Y = +1.7 feet

Centroid: $\overline{X}$ = +11.3 feet
(of impacts) $\overline{Y}$ = +42.9 feet

HIT DISTRIBUTION TEST
Flight No. 9 Test No. 6
18 February 1970

(C) This test was to be conducted over the South CBU grid for the purpose of collecting hit distribution data. The test was aborted in flight due to loss of "Pig U" mount controls. When post-flight investigation was conducted, the mount problem had disappeared. No grenade launcher firings were attempted on this test. Flight duration was fifteen minutes.

HIT DISTRIBUTION TEST
Flight No. 9A Test No. 6
18 February 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution data. Fifty-six inert rounds were fired in bursts of 6, 9, 8 and 33. Impact dispersion was 1.4, 2.8, 3.0 and 6.1 mils. Estimated aimpoint offsets were used to adjust grenade trajectory to hit the targets. The closest grenade impact occurred in Run No. 4 where grenades impacted within twenty feet of the target. Flight duration was forty-eight minutes.

Weather Conditions

Barometric Pressure: 26.90" Hg
Temperature: 59° F
Wind: 5 knots from 330° T

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Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	2000	--	60°	0°
2	30	2000	--	62°	-13°
3	30	2000	--	62°	+17°
4	30	2000	--	90°	+ 3°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	6	2.7	1.8	3.3	1.4
2	9	3.4	5.3	6.3	2.8
3	8	5.0	4.6	6.8	3.0
4	33	6.6	10.3	12.2	6.1

Impact Coordinates (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	15.2	-97.0	4	13.3	-93.5
2	10.2	-94.8	5	16.0	-96.3
3	17.7	-97.3	6	12.3	-92.9

Aimpoint:
(75 feet short of target 1)

Centroid: $\overline{X}$ = +14.1 feet
(of impacts) $\overline{Y}$ = -95.3 feet

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	34.6	-73.7	6	38.7	-64.8
2	32.2	-67.1	7	41.3	-68.7
3	39.7	-70.1	8	31.5	-59.7
4	34.6	-67.1	9	37.2	-56.9
5	38.7	-70.1			

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Aimpoint:
(75 feet short of target 5)

Centroid: $\overline{X}$ = +36.5 feet
(of impacts) $\overline{Y}$ = -66.5 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-66.1	-62.0
2	-61.2	-66.5
3	-56.4	-64.6
4	-58.2	-58.9
5	-52.5	-58.0
6	-53.9	-54.5
7	-53.5	-54.5
8	-51.2	-55.8

Aimpoint
(75 feet short of target 1)

Centroid: $\overline{X}$ = -56.6 feet
(of impacts) $\overline{Y}$ = -59.4 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-26.7	9.0
2	-15.8	-3.9
3	-18.4	4.3
4	-21.2	-1.0
5	-18.7	0
6	-21.1	5.8
7	-16.2	4.7
8	-21.1	9.2
9	-22.0	2.1
10	-22.9	8.3
11	-20.7	10.1
12	-29.7	9.1
13	-28.7	6.1
14	-27.3	-.5
15	-38.0	3.3
16	-33.7	6.4
17	-31.3	3.8
18	-32.8	5.9
19	-33.7	2.9
20	-33.7	7.6
21	-34.5	9.1
22	-35.0	11.0
23	-31.2	20.0
24	-33.6	23.0
25	-33.6	28.2
26	-33.6	27.2
27	-34.7	23.9
28	-34.3	25.7
29	-33.6	23.3
30	-29.7	25.1
31	-38.0	26.3
32	-32.2	28.5
33	-26.7	27.8

Aimpoint:
(120 feet short of target 2)

Centroid: $\overline{X}$ = -28.6 feet
(of impacts) $\overline{Y}$ = +11.9 feet

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HIT DISTRIBUTION TEST
Flight No. 10 Test No. 8
19 February 1970

(C) This test was conducted over the South CBU grid for the purpose of collecting hit distribution data. Forty-four inert rounds were fired in bursts of 6, 10, 6, 7, 6, and 9. Impact dispersion was 2.2, 3.3, 3.6, 2.1, 4.4 and 4.1 mils. The targets were used for an aiming reference only. All runs were made in hover at an altitude of 1,000 feet. Flight duration was thirty-two minutes.

Weather Conditions

Barometric Pressure: 27.04" Hg
Temperature: 51° F
Wind: 18 knots to 24 knots from 360° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	hover	1000	15°	44°	+3°
2	hover	1000	5°	35°	+3°
3	hover	1000	0°	38°	+15°
4	hover	1000	40°	90°	+10°
5	hover	1000	20°	90°	+20°
6	hover	1000	60°	85°	+18°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	6	2 4	2.0	3.1	2.2
2	10	4.0	4.0	5.7	3.3
3	6	4.0	4.3	5.9	3.6
4	7	2.0	0.8	2.1	2.1
5	6	3.7	2.4	4.4	4.4
6	9	2.4	3.3	4.1	4.1

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Impact Coordinates (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-46.2	-68.3	4	-42.7	-73.7
2	-44.2	-72.7	5	-39.6	-71.0
3	-40.7	-72.0	6	-41.9	-73.2

Aimpoint: (target 3) X = +3.8 feet, Y = +2.8 feet

Centroid: (of impacts) $\bar{X}$ = -42.6 feet, $\bar{Y}$ = -71.8 feet

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-70.9	-122.7	6	-56.3	-110.2
2	-61.6	-114.7	7	-61.1	-110.8
3	-62.3	-113.2	8	-58.5	-109.7
4	-61.1	-114.0	9	-58.9	-112.4
5	-64.8	-112.9	10	-64.0	-108.3

Aimpoint: (target 1) X = +2.2 feet, Y = +1.3 feet

Centroid: (of impacts) $\bar{X}$ = -61.9 feet, $\bar{Y}$ = -112.9 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-86.6	-137.3	4	-79.5	-135.5
2	-74.8	-129.5	5	-83.7	-142.2
3	-81.3	-139.7	6	-82.3	-138.0

Aimpoint: (target 4) X = +1.8 feet, Y = -3.4 feet

Centroid: (of impacts) $\bar{X}$ = -81.4 feet, $\bar{Y}$ = -137.0 feet

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Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	11.6	40.6	5	15.7	41.2
2	12.2	40.1	6	15.1	40.7
3	16.0	40.4	7	16.8	39.8
4	14.8	38.7			

Aimpoint: (target 9) X = +11.3 feet, Y = +10.9 feet

Centroid: (of impacts) $\overline{X}$ = +14.6 feet, $\overline{Y}$ = +40.2 feet

Run No. 5 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-38.2	52.5	4	-29.8	49.4
2	-29.8	48.6	5	-28.3	54.0
3	-29.0	50.0	6	-29.9	54.1

Aimpoint: (target 2) X = +11.3 feet, Y = +11.1 feet

Centroid: (of impacts) $\overline{X}$ = -30.8 feet, $\overline{Y}$ = 51.4 feet

Run No. 6 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (Feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	8.8	41.7	6	16.5	34.1
2	13.4	38.7	7	13.9	32.4
3	15.1	37.2	8	15.0	32.6
4	14.6	36.9	9	11.8	31.8
5	16.3	34.1			

Aimpoint: (target 10) X = +10.7 feet, Y = + 9.3 feet

Centroid: (of impacts) $\overline{X}$ = +13.9 feet, $\overline{Y}$ = +35.5 feet

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HIT DISTRIBUTION TEST
Flight No. 11 Test No. 9
19 February 1970

(c) (C) This test consisted of six firing runs at South CBU grid targets for the purpose of collecting hit distribution data. Ninety inert rounds were fired in thirteen firing bursts of 8, 5, 6, 4, 7, 7, 6, 6, 7, 5, 7, 7 and 15 rounds. Impact dispersions were 3.2, 1.9, 3.0, 4.2, 2.8, 3.2, 2.6, 1.8, 3.1, 1.4, 2.3, 2.9 and 6.2 mils. Aimpoint offsets were used to correct grenade trajectory for gravity drop. All firing bursts except the last two were executed in hover at 2,000 feet in altitude. The flight plan for the last two runs was changed because wind velocity had dropped below the level required to operate the helicopter in hover. Flight duration was forty-five minutes.

Weather Conditions

Barometric Pressure: 26.93" Hg
Temperature: 55° F
Wind: 8 knots from 360° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1 (1)	Hover	2000	20°	60°	0°
1 (2)	Hover	2000	20°	60°	0°
1 (3)	Hover	2000	40°	60°	0°
2 (1)	Hover	2000	--	60°	-15°
2 (2)	Hover	2000	50°	60°	-15°
2 (3)	Hover	2000	30°	60°	-15°
3 (1)	Hover	2000	--	60°	+15°
3 (2)	Hover	2000	--	60°	+15°
3 (3)	Hover	2000	15°	60°	+15°
4 (1)	Hover	2000	30°	90°	0°
4 (2)	Hover	2000	30°	90°	0°
5	30	1600	55°	45°	0°
6	30	1000	30°	45°	+15°

NOTE: Burst number is in parenthesis

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Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1 (1)	8	5.6	5.0	7.5	3.2
1 (2)	5	2.4	3.6	4.3	1.9
1 (3)	6	3.9	5.6	6.9	3.0
2 (1)	4	5.6	7.8	9.6	4.2
2 (2)	7	3.5	5.4	6.4	2.8
2 (3)	7	4.3	5.9	7.3	3.2
3 (1)	6	5.1	2.9	5.9	2.6
3 (2)	6	3.0	2.8	4.2	1.8
3 (3)	7	2.3	6.7	7.1	3.1
4 (1)	5	2.0	1.9	2.8	1.4
4 (2)	7	3.4	3.0	4.6	2.3
5	7	4.2	5.0	6.5	2.9
6	15	5.5	6.9	8.8	6.2

Impact Coordinates (Title Unclassified)

Run No. 1 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-87.4	-39.2	5	-81.3	-50.9
2	-86.4	-47.9	6	-77.2	-53.3
3	-83.0	-44.6	7	-72.9	-53.7
4	-85.0	-43.2	8	-74.1	-49.8

Aimpoint: (target 3) X = +6 feet, Y = +3 feet

Centroid: (of impacts) $\overline{X}$ = -80.9 feet, $\overline{Y}$ = -47.7 feet

Run No. 1 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-34.7	23.7	4	-38.2	15.5
2	-34.2	17.6	5	-32.2	14.7
3	-32.5	16.0			

Aimpoint: (target 3) X = +27 feet, Y = +60 feet

Centroid: (of impacts) $\overline{X}$ = -34.4 feet, $\overline{Y}$ = +17.5 feet

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Run No. 1 (3rd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-13.0	10.3	4	- 8.5	0
2	- 7.3	2.3	5	-10.3	-7.2
3	- 1.7	0	6	-10.9	0

Aimpoint: (target 3) X = +112 feet, Y = + 60 feet

Centroid: (of impacts) $\overline{X}$ = -8.6 feet, $\overline{Y}$ = + .9 feet

Run No. 2 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-28.4	-37.7	3	-17.3	-34.2
2	-18.6	-28.2	4	-26.7	-46.9

Aimpoint: (target 1) X = +4 feet, Y = +4 feet

Centroid: (of impacts) $\overline{X}$ = -22.7 feet, $\overline{Y}$ = -36.7 feet

Run No. 2 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	30.5	-69.3	5	37.3	-80.6
2	33.4	-64.9	6	36.1	-76.7
3	36.3	-68.0	7	41.6	-70.1
4	34.2	-71.6			

Aimpoint: (target 1) X = +44 feet, Y = +60 feet

Centroid: (of impacts) $\overline{X}$ = +35.6 feet, $\overline{Y}$ = -71.6 feet

Run No. 2 (3rd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	36.0	-52.4	5	39.7	-48.4
2	35.3	-49.5	6	47.7	-43.1
3	40.5	-47.4	7	43.5	-37.2
4	42.2	-55.1			

Aimpoint: X = +74 feet
(target 1) Y = +92 feet

Centroid: $\bar{X}$ = +40.7 feet
(of impacts) $\bar{Y}$ = -47.6 feet

Run No. 3 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-62.7	-73.4	4	-53.9	-73.7
2	-53.9	-78.2	5	-50.0	-77.7
3	-48.0	-73.0	6	-55.8	-79.7

Aimpoint: X = +4 feet
(target 4) Y = +4 feet

Centroid: $\bar{X}$ = -54.1 feet
(of impacts) $\bar{Y}$ = -75.9 feet

Run No. 3 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	15.3	66.8	4	19.5	63.7
2	23.7	66.0	5	20.0	67.0
3	18.2	60.6	6	22.6	68.5

Aimpoint: Not measured.
(50 feet beyond target 4)

Centroid: $\bar{X}$ = +19.9 feet
(of impacts) $\bar{Y}$ = +65.4 feet

Run No. 3 (3rd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	5.9	33.0	5	6.0	42.9
2	4.7	40.8	6	9.7	47.8
3	2.2	41.8	7	4.2	55.0
4	4.5	43.8			

Aimpoint: (target 4) X = +39 feet, Y = +57 feet

Centroid: (of impacts) $\overline{X}$ = +5.3 feet, $\overline{Y}$ = +43.6 feet

Run No. 4 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-1.9	21.6	4	-7.2	17.8
2	-5.8	20.7	5	-4.7	17.2
3	-6.2	19.0			

Aimpoint: (target 9) X = + 8 feet, Y = +12 feet

Centroid: (of impacts) $\overline{X}$ = - 5.2 feet, $\overline{Y}$ = 19.3 feet

Run No. 4 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-9.2	15.8	5	-10.7	6.7
2	-8.4	13.8	6	-12.8	13.2
3	-9.6	10.8	7	-18.2	13.0
4	-9.4	9.5			

Aimpoint: (target 9) X = +31 feet, Y = +12 feet

Centroid: (of impacts) $\overline{X}$ = -11.2 feet, $\overline{Y}$ = 11.8 feet

Run No. 5 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	26.8	-2.5	5	18.9	-9.6
2	26.3	-7.8	6	18.3	-4.1
3	24.7	-6.2	7	16.4	+6.0
4	22.7	-4.2			

Aimpoint: X = +1.8 feet
(target 6) Y = -6.4 feet

Centroid: $\overline{X}$ = +22.0 feet
(of impacts) $\overline{Y}$ = - 4.1 feet

Run No. 6 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-21.7	-16.5	9	-29.1	-29.2
2	-22.1	-18.7	10	-37.0	-29.3
3	-24.3	-19.0	11	-26.5	-31.2
4	-23.2	-21.8	12	-28.9	-36.2
5	-22.2	-23.0	13	-37.0	-38.6
6	-25.2	-24.7	14	-36.2	-34.2
7	-26.0	-25.4	15	-34.2	-35.5
8	-28.4	-25.6			

Aimpoint: X = -118 feet
(target 5) Y = - 48 feet

Centroid: $\overline{X}$ = -28.1 feet
(of impacts) $\overline{Y}$ = -27.3 feet

HIT DISTRIBUTION TEST
Flight No. 12 Test No. 4
20 February 1970

(C) This test consisted of seven firing runs at South CBU grid targets for the purpose of collecting hit distribution data. Sixty-one inert rounds were fired in bursts of 5, 7, 5, 4, 5, 7, 7, 8 and 14. Impact dispersion was 18.8, 2.3, 3.5, 14.9, 2.9, 2.8, 32.5, 3.7 and 61.1 mils. Aimpoint offsets were not used. All firings were executed at 60 knots ground speed and 1,000 feet in altitude. Flight duration was forty-eight minutes.

Weather Conditions

Barometric Pressure: 26.88" Hg
Temperature: 52° F
Wind: 8 to 10 knots from 30° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	1000	--	85°	0°
2 (1)	60	1000	--	46°	0°
2 (2)	60	1000	--	70°	0°
3	60	1000	--	95°	-14°
4 (1)	60	1000	--	45°	-13°
4 (2)	60	1000	--	80°	-18°
5	60	1000	--	95°	+ 7°
6	60	1000	--	48°	+15°
7	60	1000	--	48°	0°

NOTE: Burst number is in parenthesis.

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	5	2.5	18.8	19.0	18.9
2 (1)	7	2.6	1.9	3.2	2.3
2 (2)	5	1.8	3.2	3.7	3.5
3	4	5.6	13.8	14.9	14.9
4 (1)	5	3.7	1.9	4.1	2.9
4 (2)	7	2.2	1.8	2.9	2.8
5	7	5.8	32.1	32.6	32.5
6	8	3.1	4.0	5.0	3.7
7	14	5.1	82.0	82.2	61.1

Impact Coordinates (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-11.2	144.3	4	-16.7	183.3
2	-10.7	158.1	5	-14.8	190.8
3	-13.7	167.2			

Aimpoint: (target 9) X = +16 feet, Y = + 8 feet

Centroid: (of impacts) $\overline{X}$ = -13.4 feet, $\overline{Y}$ = 168.7 feet

Run No. 2 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-12.7	108.2	5	-15.2	103.7
2	- 9.0	106.2	6	-12.7	104.0
3	-10.2	103.7	7	-11.3	104.2
4	- 7.6	102.5			

Aimpoint: (target 6) X = +4 feet, Y = +1 foot

Centroid: (of impacts) $\overline{X}$ = -11.2 feet, $\overline{Y}$ = 104.6 feet

Run No. 2 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-11.0	105.2	4	- 7.9	111.0
2	-11.9	105.2	5	-12.0	111.0
3	- 9.0	111.0			

Aimpoint: (target 6) X = +6 feet, Y = +2 feet

Centroid: (of impacts) $\overline{X}$ = -10.4 feet, $\overline{Y}$ = 108.7 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-65.1	134.2	3	-70.4	153.3
2	-63.4	144.9	4	-75.8	167.0

Aimpoint: (target 2) X = -1 foot, Y = +15 feet

Centroid: (of impacts) $\overline{X}$ = -68.7 feet, $\overline{Y}$ = +149.8 feet

CONFIDENTIAL

Run No. 4 (1st burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	1.4	130.3	4	9.4	129.9
2	7.1	129.3	5	7.1	132.1
3	11.2	133.9			

Aimpoint: (target 1) X = +4 feet, Y = +4 feet

Centroid: (of impacts) $\overline{X}$ = +7.2 feet, $\overline{Y}$ = 144.8 feet

Run No. 4 (2nd burst) (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-15.5	144.8	5	-13.2	146.1
2	-18.5	142.9	6	-12.2	147.2
3	-13.2	142.5	7	-16.7	143.7
4	-14.4	146.4			

Aimpoint: (target) X = + 4 feet, Y = +19 feet

Centroid: (of impacts) $\overline{X}$ = -14.8 feet, $\overline{Y}$ = +144.8 feet

Run No. 5 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	5.6	149.4	5	3.9	205.2
2	10.5	160.8	6	-2.0	223.5
3	11.7	173.5	7	-4.0	235.4
4	3.9	193.0			

Aimpoint: (target 10) X = +11 feet, Y = + 4 feet

Centroid: (of impacts) $\overline{X}$ = + 4.2 feet, $\overline{Y}$ = +191.5 feet

CONFIDENTIAL

Run No. 6 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	4.0	136.8	5	11.4	127.5
2	11.4	127.5	6	7.8	133.5
3	9.9	129.7	7	14.2	133.2
4	8.6	130.1	8	11.4	137.8

Aimpoint: (target 5) X = +4 feet, Y = +4 feet

Centroid: (of impacts) $\overline{X}$ = + 9.8 feet, $\overline{Y}$ = +132.0 feet

Run No. 7 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	10.2	133.9	8	17.0	170.1
2	15.0	126.6	9	15.6	194.2
3	16.2	132.4	10	10.0	227.7
4	18.4	133.7	11	7.3	270.8
5	14.7	131.7	12	10.6	300.0
6	18.8	139.6	13	4.3	327.2
7	17.6	148.0	14	4.0	357.7

Aimpoint: (target 3) X = +4 feet, Y = +4 feet

Centroid: (of impacts) $\overline{X}$ = + 12.8 feet, $\overline{Y}$ = +199.5 feet

STRAFING TEST
Flight No. 13 Test No. 7
26 February 1970

(U) This test consisted of five strafing runs over the South CBU grid. All runs were made at 60 knots and 2,000 feet altitude. No hit distribution data were obtained. Flight duration was forty-six minutes.

STRAFING TEST
Flight No. 14 Test No. 10
26 February 1970

(C) This test consisted of two strafing runs executed over the South CBU grid for the purpose of demonstrating the strafing capability of the NITE GAZELLE/Grenade Launcher Weapon System. The firing bursts were made at a helicopter ground speed of 60 knots and an altitude of 600 feet. One hundred thirty grenades were fired in two long bursts of 67 and 63 rounds. Plots of the impact patterns follow. Flight duration was twenty-three minutes.

Weather Conditions

Barometric Pressure: 26.86" Hg
Temperature: 65°F
Wind: 3 to 5 knots from 360° T

Flight and Mount parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	60	600	0°	17° - 50°	0°
2	60	600	15°	17° - 50°	0°

HIT DISTRIBUTION TEST
Flight No. 15 Test No. 11
26 February 1970

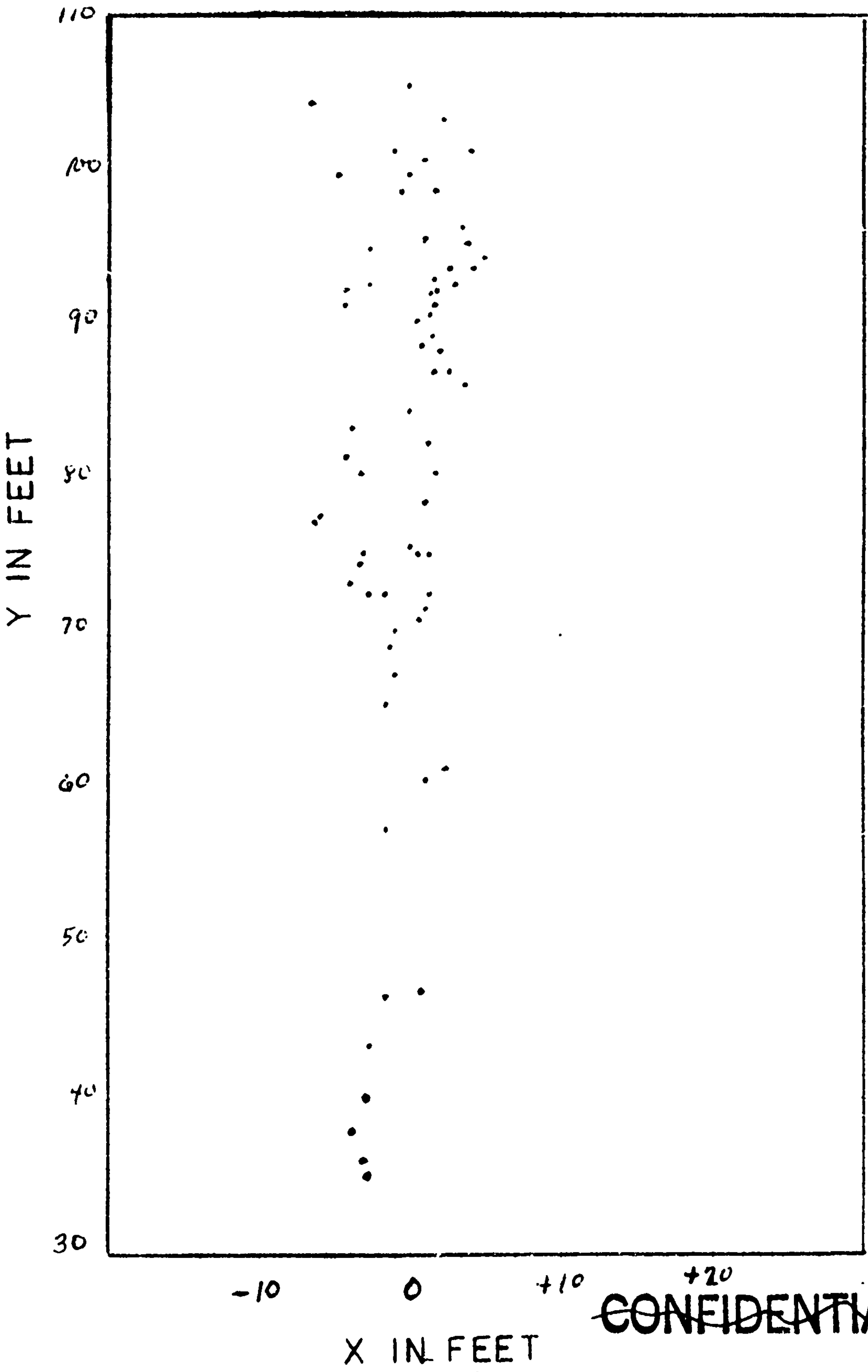
(C) This test consisted of five runs over the South CBU grid for the purpose of obtaining hit distribution data. The first run was a strafing run and was not scored. Forty-eight inert rounds were fired in the remaining four runs in bursts of 9, 10, 11 and 8. Impact dispersion was 2.5, 2.5, 2.3 and 2.2 mils. Targets were used for aimpoint references only. No aimpoint offsets were applied. Flight duration was sixty-eight minutes.

Weather Conditions

Barometric Pressure: 26.70" Hg
Temperature: 68°F
Wind: 3 knots from 360° T

CONFIDENTIAL

FLIGHT NO. 14
STRAFING RUN NO. 1
26 FEBRUARY 1970
IMPACT PATTERN



CONFIDENTIAL

9-C31

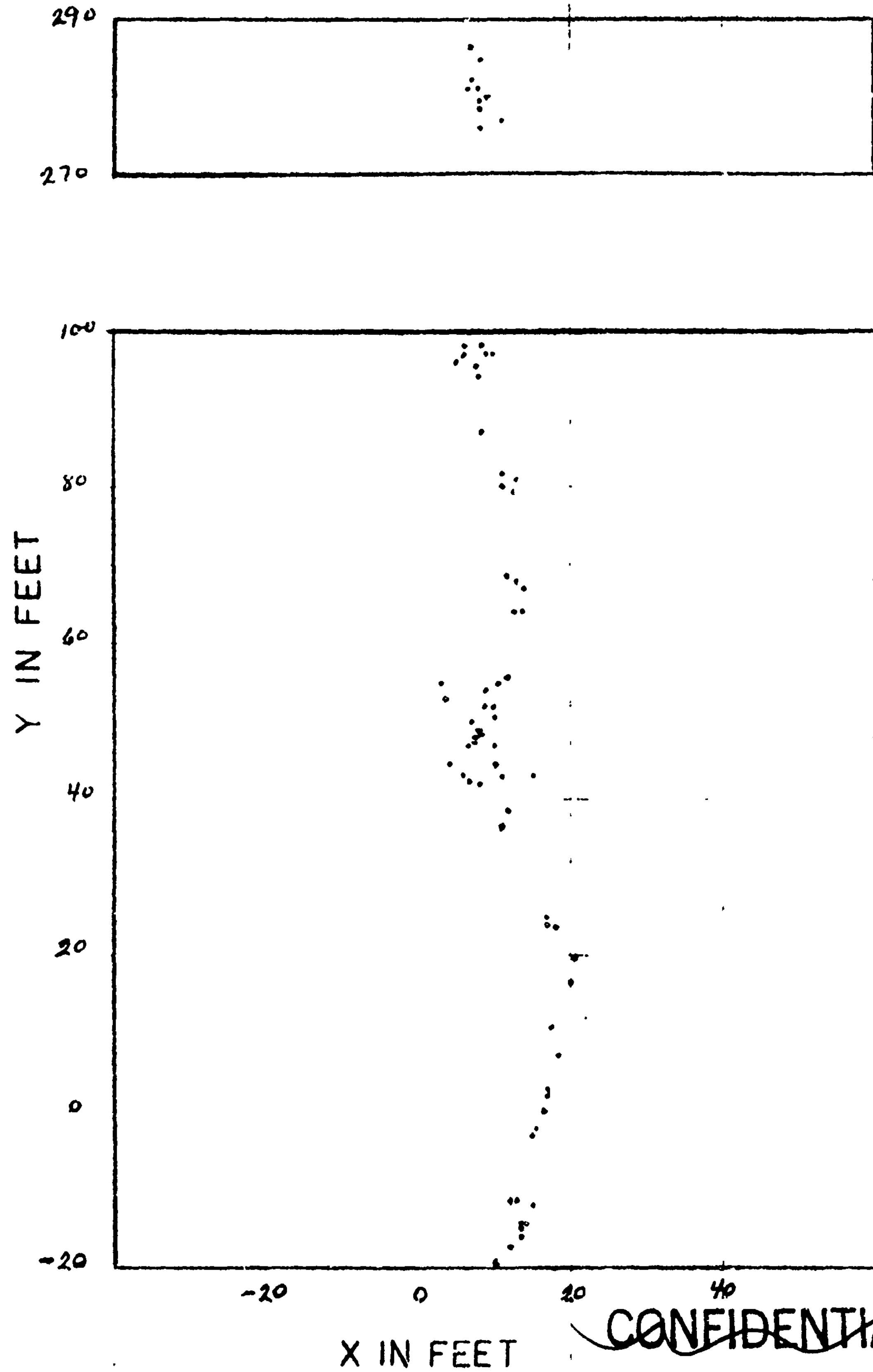
CONFIDENTIAL

FLIGHT NO. 14

STRAFING RUN NO. 2

26 FEBRUARY 1970

IMPACT PATTERN



CONFIDENTIAL

CONFIDENTIAL

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Heading (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
2	60	3000	35°	90°	4°
3	60	3000	50°	60°	0°
4	30	3000	55°	90°	-19°
5	30	3000	30°	63°	0°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
2	9	3.5	6.5	7.4	2.5
3	10	6.5	5.4	8.5	2.5
4	11	5.3	4.1	6.7	2.3
5	18	4.2	6.3	7.5	2.2

Impact Coordinates (Title Unclassified)

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-223.3	166.8	6	-219.0	184.3
2	-217.4	178.5	7	-220.5	181.4
3	-216.3	178.5	8	-223.5	187.1
4	-213.5	184.9	9	-221.8	187.7
5	-216.2	177.0			

Aimpoint: (target 9) X = +8 feet, Y = -4 feet

Centroid: (of impacts) $\overline{X}$ = -219.1 feet, $\overline{Y}$ = +180.7 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	402.5	196.8	6	415.3	194.9
2	418.9	183.3	7	423.9	193.8
3	417.5	183.3	8	423.9	192.8
4	419.4	183.3	9	423.9	184.7
5	420.3	188.3	10	423.5	193.3

CONFIDENTIAL

Aimpoint: X = -11 feet
(target 3) Y = -19 feet

Centroid: $\overline{X}$ = +418.9 feet
(of impacts) $\overline{Y}$ = +189.5 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-256.9	31.0	7	-245.6	27.0
2	-255.8	21.2	8	-244.7	26.5
3	-249.7	27.9	9	-244.3	30.2
4	-254.5	23.4	10	-258.6	31.5
5	-251.8	28.3	11	-247.4	35.6
6	-245.3	32.4			

Aimpoint: X = +8 feet
(target 9) Y = +4 feet

Centroid: $\overline{X}$ = -250.4 feet
(of impacts) $\overline{Y}$ = 28.6 feet

Run No. 5 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	51.2	44.2	10	51.2	57.2
2	52.4	47.5	11	51.2	59.5
3	47.2	44.7	12	57.2	53.3
4	52.4	47.2	13	55.1	58.7
5	44.3	47.2	14	56.8	57.5
6	45.7	47.2	15	52.9	55.3
7	52.4	43.7	16	51.7	60.3
8	42.7	45.8	17	52.9	59.1
9	56.3	57.2	18	54.7	58.7

Aimpoint: X = +2 feet
(target 3) Y = +2 feet

Centroid: $\overline{X}$ = +51.6 feet
(of impacts) $\overline{Y}$ = +52.5 feet

CHECK FLIGHT
Flight No. 16 Test No. -
1 April 1970

(U) Flight No. 16 was a check flight in preparation for night demonstrations. All systems checked out. Flight duration was twenty-four minutes.

CONFIDENTIAL

NIGHT FIRING DEMONSTRATION
Flight No. 17 Test No. 40
1 April 1970

(C) This test was a night demonstration using the ITT Low Light Level Television System. Lift-off occurred at 2025 local time. The purpose of the test was to acquire track and fire on a stationary truck under low light level conditions. Sources of illumination in the vicinity of the target were 1) an ECOM Big Light, 2) a bonfire and 3) headlight on a truck. The test was cancelled in flight due to poor TV performance. Test duration was forty-five minutes.

FIRING DEMONSTRATION
Flight No. 18 Test No. 41
3 April 1970

(U) This test was conducted to fire high explosive rounds against stationary trucks. One dry run and two firing runs were accomplished. The flight was cancelled in flight when the gun would not fire in the fourth run. The gun jammed because one round entered the gun in a cocked position. Flight duration was thirty-two minutes.

(C) The results of the two firing runs as viewed on TV monitor in real time and recorded in the Test Conductor's Logs are as follows:

In the first firing burst (Run No. 2), the rounds impacted on target in a tight cluster around the engine compartment of the truck.

In the second firing run (Run No. 3), the rounds impacted 15 to 20 feet to the right of the truck. The "Big U" mount hit an azimuth stop spoiling the aim.

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Depression Angle (degrees)	Pan Angle (degrees)
1	hover	1000	70° - 90°	0°
2	hover	1000	70° - 90°	0°
3	hover	1000	70° - 90°	0°
4	hover	1000	70° - 90°	0°

 CONFIDENTIAL

DRESS REHEARSAL FOR
NIGHT FIRING DEMONSTRATION
Flight No. 19 Test No. 40B
23 April 1970

(U) This test was a dress rehearsal for Test 40 and Test 40A, night demonstrations using the Low Light Level Television System. Lift-off occurred at 1434 local time and flight duration was forty-nine minutes.

(C) Test results as observed on TV monitor are as follows: The test targets were acquired and identified over the Low Light Level TV System. There was one dry run and two firing runs. On the first firing run, the rounds impacted within five feet of the target. On the second firing run, the rounds impacted 15 feet beyond the target. A post-flight boresight check showed a two mil shift due to firing stress.

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	1600	45°	0°
2	30	1600	45°	0°
3	30	1600	45°	0°

NIGHT FIRING DEMONSTRATION
Flight No. 20 Test No. 40
23 April 1970

(U) This test was a night firing demonstration using the Low Light Level TV and high explosive ammunition. Lift-off occurred at twilight, 1852 local time.

(C) Test results as observed by TV monitor and recorded in the Test Conductor's Logs were described as follows:

> One dry run and two firing runs were accomplished. On the first firing run, the target was acquired with the only light source being flares dropped from an aircraft ten miles to the north. The grenade firings impacted 50 feet low and to the left. On the second firing run, the rounds impacted low and to the left of the target by 30 to 40 feet.
>
> It was recorded that direct viewing of the Big Light, truck headlights and the lights of Las Vegas produced a gain change in the camera. The camera recovers within two seconds after the bright light leaves the field of view.

CONFIDENTIAL

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	1600	45°	0°
2	30	1600	45°	0°
3	30	1600	45°	0°

NIGHT FIRING DEMONSTRATION
Flight No. 21 Test No. 40A
23 April 1970

(C) This test was a night firing demonstration using the Low Light Level TV System. The mission was cancelled in flight due to failure of the gun to fire. A post-flight inspection showed a sheared pin in the gun drive shaft between the motor and the gun mechanism. Flight duration was twenty minutes.

FIRING DEMONSTRATION
Flight No. 22 Test No. 41
24 April 1970

(C) This test was cancelled in flight due to gun jamming. Post-flight inspection revealed a broken link in the ammunition belt, which was repaired. Flight duration was twenty-seven minutes.

FIRING DEMONSTRATION
Flight No. 23 Test No. 41
24 April 1970

(C) This test consisted of one dry run and three firing runs conducted with high explosive ammunition fired against stationary trucks. Round impacts were charted. Flight duration was nineteen minutes.

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	hover	1000	70° - 90°	0°
2	hover	1000	70° - 90°	0°
3	hover	1000	70° - 90°	0°
4	hover	1000	70° - 90°	0°

 CONFIDENTIAL

FIRING DEMONSTRATION
Flight No. 24 Test No. 42
30 April 1970

(U) This test was cancelled in flight due to no mount control from the control van. Flight duration was eighteen minutes. Post-flight investigation showed the pitch axis motor was defective. The motor was replaced.

FIRING DEMONSTRATION
Flight No. 25 Test No. 42
5 May 1970

(C) This was a firing demonstration using high explosive ammunition against stationary trucks. The flight consisted of one dry run and three firing runs. Flight duration was forty-three minutes.

(C) Test results as observed on TV monitor and recorded in the Test Conductor's Log are as follows:

On the first firing run (Run No. 2). the aiming point burst hit behind the truck; the five-second firing burst hit in front of and walked up to the truck which blew up. (The burst hit the gas tank and set it off.)

On the second firing run (Run No. 3), both the aiming burst and the firing burst hit behind the truck.

On the third firing run, the aiming burst hit behind the truck; the firing burst hit in front of and walked up to the truck.

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (degrees)	Depression Angle (degrees)	Pan Angle (degrees)
1	hover	1000	70° - 90°	0°
2	hover	1000	70° - 90°	0°
3	hover	1000	70° - 90°	0°
4	hover	1000	70° - 90°	0°

SECTION C-2
TWIN TURRET MOUNT

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 12
4 March 1970

(U) This test was conducted to confirm proper alignment between the XM-129 grenade launcher and the TV reticle, which is used for gun aiming. The XM-129 grenade launcher had been parallel boresighted (collimated) with the TV camera.

(C) The grenade launcher was mounted in the M5 Twin Turret configuration on the helicopter. The helicopter was resting on the pad with power on and rotors turning. Five 10 to 20 round firing bursts were made at boresighting targets placed 1,000 inches from the gun. The testing stopped when all boresighting targets were expended. The calibration tests were unsuccessful due to TV camera vibration and shifting TV aimpoint.

CHECK FLIGHT
Flight No. - Test No. -
4 March 1970

(U) All systems functioned properly on this nonfiring check flight. Flight duration was nine minutes.

HIT DISTRIBUTION TEST
Flight No. 1 Test No. 1A
5 March 1970

(U) This test was scheduled to execute six firing runs over the South CBU grid for the purpose of obtaining hit distribution data. An airspeed of 30 knots and an altitude of 600 feet were planned

(U) This test was aborted in flight due to loss of TV signal. No firing runs were attempted. Flight duration was thirty-six minutes.

HIT DISTRIBUTION TEST
Flight No. 2 Test Nos. 1A & 3
5 March 1970

(U) This test was scheduled for twelve firing runs over the South CBU grid for the purpose of obtaining hit distribution data. The first six runs (Test No. 1A) were planned for an airspeed of 30 knots and an altitude of 600 feet. The second six runs were planned for an airspeed of 30 knots and an altitude of 600 feet.

(C) This test was aborted in flight because the gun jammed. The gun jammed after firing only one round in the first firing run. Flight duration was twenty minutes.

BORESIGHTING AND CALIBRATION
Flight No. - Test No. 12A
18 March 1970

(U) This test was conducted to confirm proper alignment between the XM-129 grenade launcher and the TV reticle, which is used for gun aiming. The XM-129 grenade launcher had been parallel boresighted (collimated) with the TV camera.

(C) The grenade launcher was mounted in the M5 Twin Turret configuration of the helicopter. The helicopter was resting on the pad with power on and rotors turning. One calibration burst of between ten and twelve rounds was fired at a canvas target 1,000 inches from the gun. A good hit pattern resulted. The test was completed.

HIT DISTRIBUTION TEST
Flight No. 3 Test Nos. 1A & 2A
20 March 1970

(U) This test was scheduled for ten firing runs over the South CBU grid for the purpose of obtaining hit distribution data. Test No. 1A was to consist of six firing runs at an airspeed of 30 knots and an altitude of 600 feet. Test 2A was planned to consist of four firing runs at an airspeed of 60 knots and an altitude of 600 feet.

(C) This test was aborted in flight because the gun jammed. The gun jammed after firing one round in the first firing run. No impact data was obtained. Flight duration was twenty-four minutes.

(C) Corrective action was taken to avoid the gun jamming problem. The squirrel cage feed on the ammunition track was removed, the shear pin on the gun was replaced and only fifty rounds were loaded into the ammunition box.

HIT DISTRIBUTION TEST
Flight No. 4 Test No. 1A
23 March 1970

(U) This test was planned to test fire over South CBU grid targets for the purpose of obtaining hit distribution data. The flight plan called for an airspeed of 30 knots and an altitude of 600 feet.

(C) This test was aborted in flight because the gun jammed. No firings were observed and no impact data was obtained. Flight duration was twenty minutes.

(C) Corrective action was attempted in order to remedy the gun jamming problem. The feed chute was realigned and the 90 degree turn in the feed chute was removed.

HIT DISTRIBUTION TEST
Flight No. 5 Test No. 1A
23 March 1970

(U) This test was scheduled for firing inert rounds over the South CBU grid for the purpose of obtaining hit distribution data. The flight plan designated an airspeed of 30 knots and an altitude of 600 feet.

(C) This test was aborted in flight due to failure of the gun to fire. Flight duration was sixteen minutes.

(C) Post-flight inspection revealed a sheared pin in the gun mechanism. The gun was repaired.

HIT DISTRIBUTION TEST
Flight No. 6 Test No. 1A
23 March 1970

(U) This test was scheduled for firing inert rounds over the South CBU grid for the purpose of collecting hit distribution data. The flight plan designated an airspeed of 30 knots and an altitude of 600 feet.

(C) This test was aborted in flight because the gun jammed after firing only one round.

(C) A special test was designed to troubleshoot the gun jamming problem.

FEED CHUTE FUNCTION TEST
Flight No. - Test No. -
24 March 1970

(C) The Feed Chute Function Test was designed to troubleshoot the gun jamming problem. This flight test was conducted over the lake bed with firing runs, but no targets. Ground based documentary cameras filmed the helicopter/weapon system during firing bursts. Two bursts were fired, of nine and ten rounds, at a depression angle of 45 degrees. The gun operated satisfactorily. Flight duration was thirty minutes.

(C) Maximum pressure in the feed chute, the cause of the gun jamming problem, occurs at a depression angle of 90 degrees and decreases at lesser depression angles.

HIT DISTRIBUTION TEST
Flight No. 9 Test Nos. 1A & 2A
25 March 1970

(C) This test consisted of nine firing runs over South CBU grid targets for the purpose of collecting hit distribution data. Ninety-eight rounds were fired in nine firing bursts. Impact scoring was done via TV video and therefore is not as accurate as the impacts measured in the field. Grenade impacts were observable on seven of the nine firing bursts. Impact dispersions were 20, 39, 22, 14, 60, 26 and 12 mils. The targets were used as aiming references only. No gravity drop corrections were applied. Flight duration was sixty-one minutes.

<u>Weather Conditions</u>

Barometric Pressure: 26.79" Hg
Temperature: 63°F
Wind: 4 knots from 300°T

CONFIDENTIAL

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	600	90°	0°
2	30	600	50°	+3°
3	30	600	90°	-15°
4	30	600	45°	-15°
5	30	600	90°	+15°
6	30	600	45°	+15°
7	60	600	80°	+10°
8	60	600	45°	+ 5°
9	60	600	90°	-15°

Dispersion of Impacts (Title Unclassifed - Table Confidential)

Run No.	No. of Rounds*	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	7	8	9	12	20
2	16	15	29	33	39
3	5	12	5	13	22
4	7	10	7	12	14
5	--	--	--	--	--
6	--	--	--	--	--
7	15	10	35	36	60
8	10	13	18	22	26
9	3	5	5	7	12

*No. of rounds observed impacting

Impact Coordinates (as observed on TV) (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-42	+92	5	-48	+70
2	-51	+82	6	-41	+79
3	-54	+76	7	-34	+90
4	-58	+69			

Aimpoint:
(target No. 2)

Centroid: $\overline{X}$ = -47 feet
(of impacts) $\overline{Y}$ = +80 feet

CONFIDENTIAL

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	- 8	+60
2	- 2	+62
3	+ 5	+58
4	+10	+55
5	+16	+50
6	+20	+40
7	+22	+32
8	+24	+25
9	+25	+ 2
10	+22	- 2
11	+18	- 8
12	+ 8	-12
13	0	-13
14	-10	-11
15	-18	- 4
16	-18	+12

Aimpoint: (target No. 3)

Centroid: (of impacts) $\overline{X}$ = + 7 feet, $\overline{Y}$ = +21 feet

Run No. 3 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	+44	+22
2	+54	+30
3	+64	+30
4	+70	+28
5	+75	+20

Aimpoint: (target No. 2)

Centroid: (of impacts) $\overline{X}$ = +61 feet, $\overline{Y}$ = +26 feet

Run No. 4 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	+18	+15
2	+17	+ 6
3	+14	0
4	+ 6	- 4
5	0	- 4
6	-4	+ 2
7	-6	+ 8

Aimpoint: (target no. 1)

Centroid: (of impacts) $\overline{X}$ = +6 feet, $\overline{Y}$ = +3 feet

CONFIDENTIAL

Run No. 5 (Table Confidential)

Impacts were not seen on TV

Run No. 6 (Table Confidential)

Impacts were not seen on TV

Run No. 7 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-42	+68
2	-39	+74
3	-36	+79
4	-34	+86
5	-32	+92
6	-30	+98
7	-28	+108
8	-24	+118
9	-22	+127
10	-19	+135
11	-17	+142
12	-15	+152
13	-14	+158
14	-14	+166
15	-12	+172

Aimpoint:
(target no. 2)

Centroid: $\overline{X}$ = - 25 feet
(of impacts) $\overline{Y}$ = +118 feet

Run No. 8 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-66	+60
2	-60	+58
3	-55	+52
4	-51	+50
5	-42	+42
6	-39	+39
7	-35	+32
8	-32	+22
9	-30	+15
10	-30	+10

Aimpoint:
(target no. 1)

Centroid: $\overline{X}$ = -44 feet
(of impacts) $\overline{Y}$ = +38 feet

 CONFIDENTIAL

Run No. 9 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	-78	+95
2	-74	+100
3	-68	+105

Aimpoint: (target no. 2)

Centroid: (of impacts) $\overline{X}$ = - 73 feet, $\overline{Y}$ = +100 feet

HIT DISTRIBUTION TEST
Flight No. 10 Test Nos. 8A & 9A
25 March 1970

(U) This test was scheduled for firing runs over the South CBU grid for the purpose of obtaining hit distribution data. Test Nos. 8A and 9A were to be conducted on this flight. The flight plan for Test 8A designated firings in hover at an altitude of 1,000 feet. Test 9A called for firings in hover at an altitude of 2,000 feet.

(C) This test was aborted in flight because the gun jammed after firing two rounds in the first run. No impact data were obtained. Flight duration was twenty minutes.

HIT DISTRIBUTION TEST
Flight No. 11 Test No. 3A
25 March 1970

(C) This test was conducted over the South CBU grid for the purpose of obtaining hit distribution data. Three firing runs were executed; the gun jammed in the fourth run and the flight was aborted. Grenade impacts were scored via TV video on the first two runs, which consisted of a four round burst and a five round burst. Impact dispersion was 15 and 18 mils. Grenade impacts were not observed on the third run. Flight duration was twenty-five minutes.

(C) Post-flight inspection revealed rounds jammed in the lower end of the feed chute. The gun was reloaded with just enough ammunition to fill the feed chute.

CONFIDENTIAL

Weather Conditions

Barometric Pressure: 26.50" Hg
Temperature: 63°F
Wind: 2 knots from 60° T

Flight and Mount Parameters (Title Unclassified - Table Confidential)

Run No.	Ground Speed (knots)	Altitude (feet)	Depression Angle (degrees)	Pan Angle (degrees)
1	30	1000	90°	- 3°
2	30	1000	45°	- 2°
3	60	1000	90°	-13°
4	60	1000	45°	0°

Dispersion of Impacts (Title Unclassified - Table Confidential)

Run No.	No. of Rounds*	S_x (feet)	S_y (feet)	S_r (feet)	S_r (mils)
1	4	5	14	15	15
2	5	24	10	25	18

*No. of rounds observed impacting

Impact Coordinates (as observed from TV) (Title Unclassified)

Run No. 1 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	+22	+62	3	+12	+83
2	+16	+72	4	+10	+95

Aimpoint:
(target no. 2)

Centroid: $\overline{X}$ = +15 feet
(of impacts) $\overline{Y}$ = +78 feet

 CONFIDENTIAL

Run No. 2 (Table Confidential)

Round No.	Impact Point X (feet)	Impact Point Y (feet)	Round No.	Impact Point X (feet)	Impact Point Y (feet)
1	+20	-20	4	-23	-26
2	+20	-32	5	-23	-42
3	+20	-42			

Aimpoint:
(target no. 2)

Centroid: $\overline{X}$ = + 3 feet
(of impacts) $\overline{Y}$ = -32 feet

HIT DISTRIBUTION TEST
Flight No. 12 Test No. 3A
26 March 1970

(U) This test was scheduled to conduct firing runs over the South CBU grid for the purpose of collecting hit distribution data. The flight plan called for airspeeds of 30 and 60 knots, and altitudes of 1,000, 1,500 and 2,000 feet.

(C) This test was aborted in flight because the gun jammed. The gun failed to fire in the first run. A shallow firing angle (depression angle of 38°) was attempted in order to free the gun. A nine round burst was fired. The gun jammed again on a rerun of the first run. Flight duration was thirty-one minutes.

APPENDIX D

DEFINITIONS AND FORMULAE

1.0 INTRODUCTION

(U) This appendix contains the definitions and formulae used in the analysis of the Grenade Launcher test program.

2.0 DEFINITIONS AND FORMULAE

(U) Altitude represents the helicopter altitude above ground level. Ground level is approximately 3,000 feet above sea level at the test site. Helicopter altitude is obtained from an on board barometric pressure gauge.

(U) Heading represents the direction of helicopter ground speed referenced to the South CBU grid lines which run 335° T. Helicopter heading was obtained from measuring the angle of the grid lines on the mount camera film or on TV video, and subtracting out the pan angle.

(U) Depression Angle represents the angle of mount tilt measured down from the horizontal plane. A 90° depression angle points the weapon and sensors straight down.

(U) Pan Angle represents the azimuth of the mount with respect to the helicopter. A positive angle means the mount is turned to the right.

(U) Dispersion is described using one-sigma standard deviations. S_x is the standard deviation in the X coordinate; S_y is the standard deviation in the Y coordinate; and S_r is the resultant standard deviation.

(U) Standard Deviation is computed by the formula,

$$\text{Stan. Dev.} = \sqrt{\frac{\Sigma x_i^2 - n\bar{x}^2}{N-1}}$$

where $\overline{X}$ is the arithmetic mean of the set, X_i, and (N-1) is the degrees of freedom.

(U) The (X, Y) coordinate system is aligned with the grid and is defined as follows:

> The positive X axis is 65° clockwise from true north,
> The positive Y axis is 335° clockwise from true north,
> and the origin is the lefthand lower corner of the reference target.

(U) Aimpoint coordinates (X, Y) are in the above coordinate system with the origin at the lefthand lower corner of the reference target.

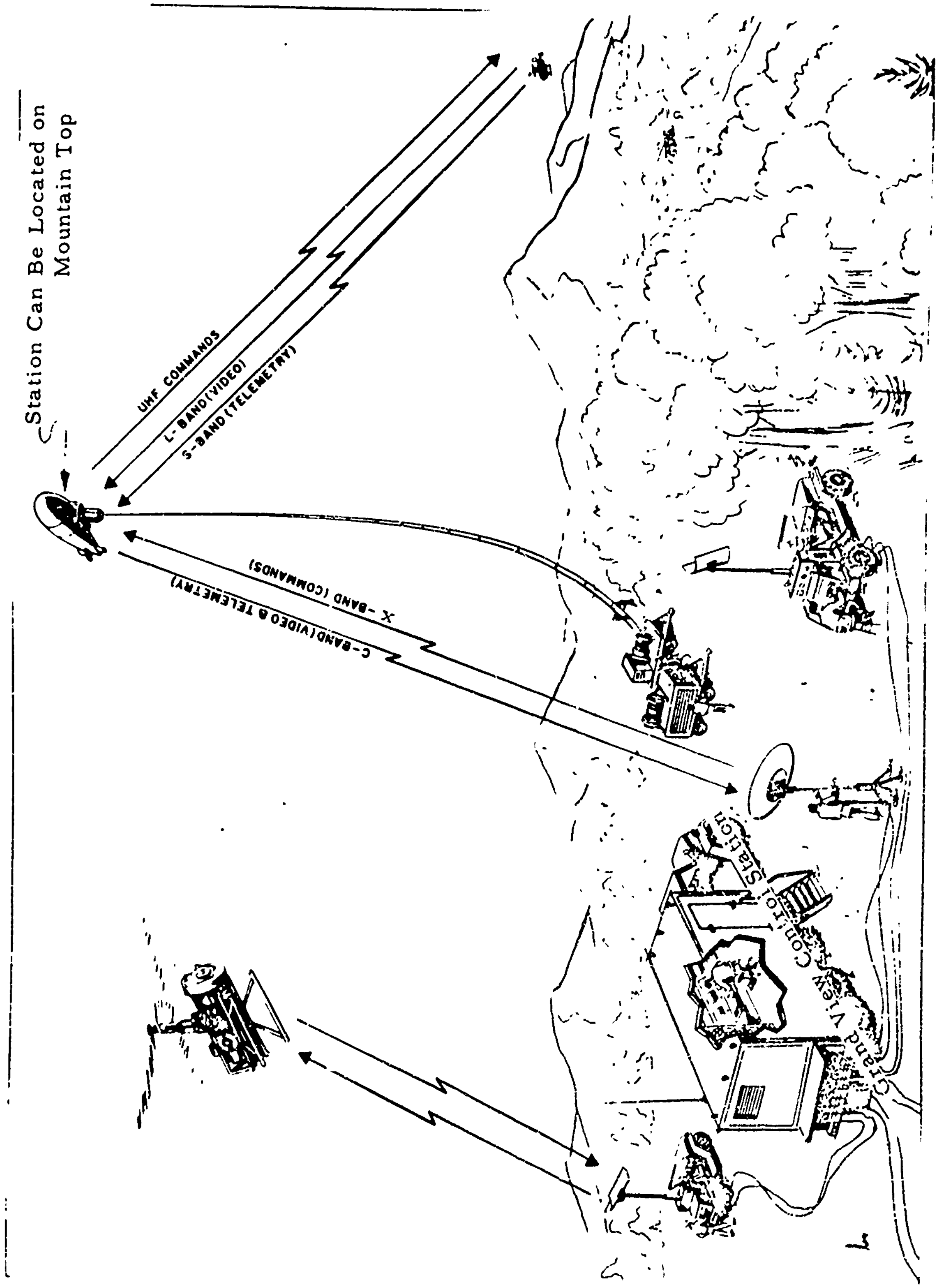
(U) The Centroid of the impacts ($\overline{X}$, $\overline{Y}$) is represented by the arithmetic means of the measured impact points (X_i, Y_i).

10.0 NITE GAZELLE/GRAND VIEW RELAY SYSTEM (U)

ABSTRACT

(C) The NITE GAZELLE/Grand View Relay System was tested at Nellis Air Force Base, Nevada from 18 June 1970 through 12 November 1971. Thirty-three flight tests and six ground tests were conducted to determine the compatibility of Grand View and NITE GAZELLE systems, to develop procedures to switch helicopter from direct to relay control, and to continuously provide a two-way relay of command, response and TV signals.

(C) Testing with the airborne portion of the system installed on Angel Peak demonstrated that the system could transmit a television picture over a distance of 100 miles and relay it to the ground control station with no degradation of picture quality. The Nellis range configuration limited helicopter flights to a distance of 40 miles from the relay station. The flight controller selected the relay mode of operation at various ranges from the launch area and helicopter control and data signals were relayed through the Grand View Relay System while the helicopter was flown on many different flight paths at altitudes varying from 150 feet to 1,500 feet, and airspeeds from hover to 55 knots.



NITE GAZELLE/GRAND VIEW RELAY SYSTEM

FIGURE 1

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the Grand View Relay System. This system was tested at Nellis Air Force Base, Nevada from 18 June 1970 through 12 November 1971. The relay system was tested by continuously relaying command and response data while the helicopter was in the pad area, making flight checks over the dry lake bed, and flown at extended ranges.

(C) The Grand View Relay System is an important part of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems, conceived to counter enemy infiltration along the roads and waterways of Southeast Asia. The remotely piloted NITE GAZELLE helicopter was equipped with sensors to provide real time navigation, target acquisition and optical fire control capability under both day and low light level conditions of night. Weapons were selected to destroy a wide variety of fixed, hard and moving targets. The Grand View Relay System extends the control range of the NITE GAZELLE helicopters from normal ground line of sight to 100 miles by relaying command signals from the ground station to the helicopter, and by relaying response and sensor data from the helicopter to the ground station.

(C) During the Nellis test program 39 tests were completed. They demonstrated that the NITE GAZELLE helicopter can be flown by relaying command signals through the relay station, and that response and sensor data from the helicopter can be relayed to the ground station and used by the helicopter controller.

2.0 RESULTS

2.1 Summary of Results

(C) The ARPA Grand View Relay test program demonstrated that the system can extend the operational range of the NITE GAZELLE helicopter by relaying command, television and telemetry signals from the helicopter to the ground control station. After the concept was demonstrated by hard wiring the systems together, the field test program proceeded in phases that resulted in the objective of extended range flights, under full relay control, being achieved in November 1971.

(C) The significant events of the test program are shown in Table 1. A summary of all scheduled test activity is listed in Appendix B. Appendix C contains test objectives, flight plans and results of all completed tests.

TABLE 1 (Title Unclassified/Table Confidential)

SUMMARY OF RESULTS

Event	Date	Summary
Check out of Grand View equipment on NITE GAZELLE	June 1970	The helicopter antenna deployed and stowed correctly. Antenna controls were used to select proper antenna quadrant.
Telemetry and Television Relay	July 1970	Television and telemetry signals from the helicopter were relayed through Grand View to the flight controller.
Long Range Television Relay	Aug. 1970	Television signals were successfully transmitted over a distance of 100 miles.
Multipath Evaluation	Dec. 1970	Measurements show that multipath causes the received signal to be as much as 15 dB below expected. They also demonstrated that extended range testing was feasible.
Command Hand Over	Dec. 1970	The helicopter was flown by command signals relayed through Grand View. Telemetry and television signals were also relayed.
Extended Range Helicopter Flignts	Nov. 1971	The helicopter was flown to a range of approximately 40 miles from the relay station.

2.2 Discussion of Test Results

(C) The Nellis test program was conducted with the airborne portion of the Grand View Relay System installed on Angel Peak. A different antenna was substituted for the normal up and down link antennas of the airborne relay. The prototype relay equipment used at Angel Peak is shown in Figure 2.

2.2.1 Interface and Compatibility Tests

(C) The newly installed Grand View antenna on the helicopter was flight tested in June 1970. TV signals were transmitted directly from the helicopter to the ground control station. Poor TV performance during the flight was caused by incorrectly wired antenna switch positions on the control console. When wiring changes were made, the correct antenna was selected and TV transmission was excellent. These tests demonstrated helicopter capability to begin testing in the relay mode.

2.2.2 Telemetry and Television Relay

(C) In July 1970, tests were conducted to evaluate the relayed telemetry and television signals. Television signals received directly from the helicopter and the signals received from the relay station were displayed for evaluation in one ground control station. Another ground control station was instrumented to evaluate the direct and relayed telemetry signals.

(C) The initial flight checks isolated several hardware and procedural problems. When these were eliminated, comparative signal strength measurements taken with the helicopter in a hover position over the pad showed that performance was equal to the design calculations. Signal strength data obtained from the flight patterns flown over the desert floor at various headings, altitudes and airspeeds, indicated several locations where the relayed telemetry and television signals were not satisfactory. Analysis of the helicopter location with respect to the Grand View relay station revealed that multipath signal reception caused the received signals to be unsatisfactory at these locations. Flights were made to determine altitudes and headings that would minimize the multipath problem. Although the signal interruptions were of a short duration and should not cause any operational problems, an equipment change was made that increased the telemetry signal by 8 dB. This change improved the telemetry signal but the multipath problem was considered to be serious enough to require additional study.

2.2.3 Command and Hand Over Tests

(C) After testing demonstrated successful relay of the telemetry and television signals, tests were conducted to fly the helicopter by commands relayed through Grand View. The helicopter was flown for over ninety minutes, on two flights, with the command signals relayed through Grand View. There was no loss of control. In addition to flight control, commands for weapons, sensors

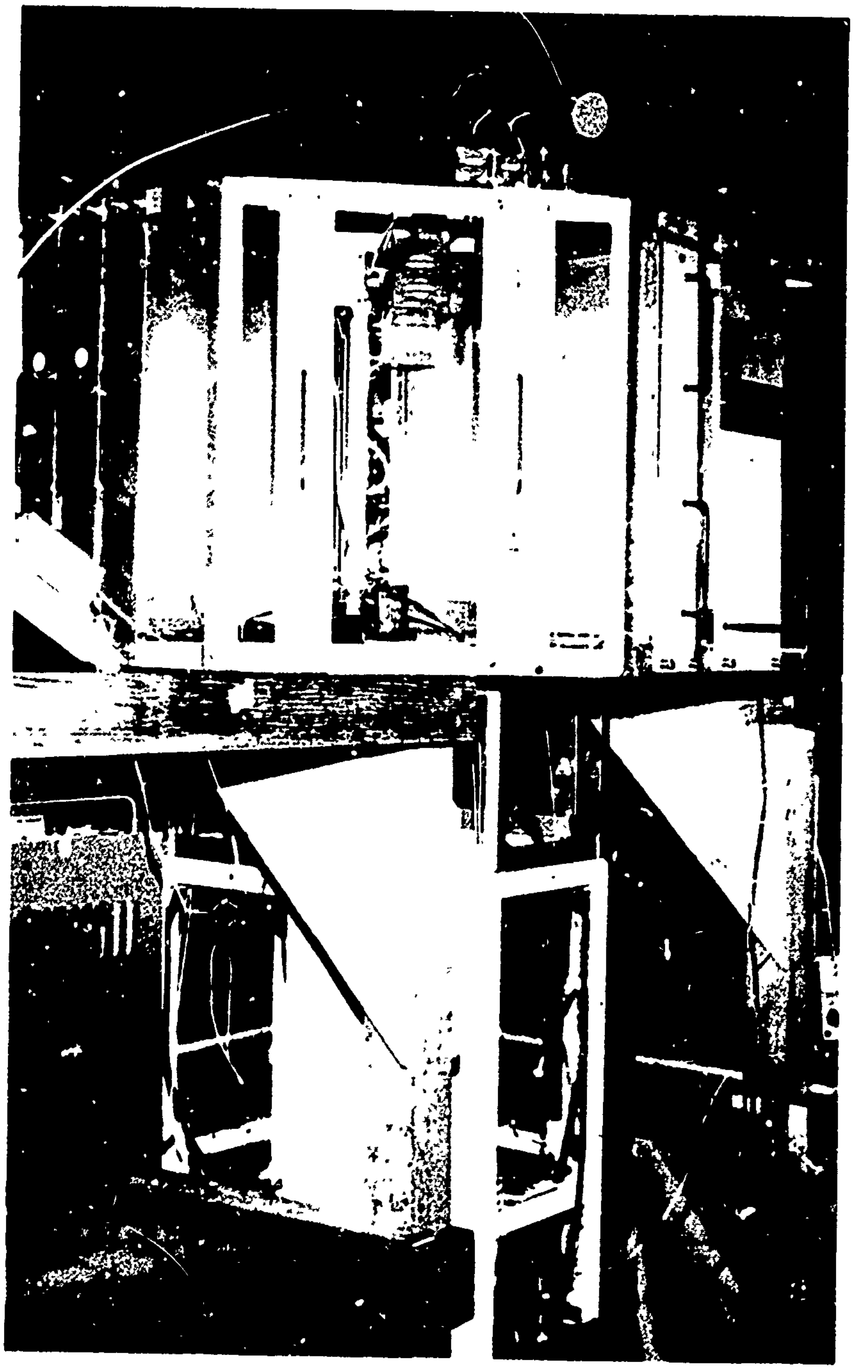


Figure 2 Grand View Prototype Installation

and mount control were also relayed. Generation and execution of all commands were verified.

2.2.4 Multipath Measurements

(C) A manned helicopter was used for the multipath test. The NITE GAZELLE TV transmitter and antenna were used and signal strength data were recorded at Angel Peak while the helicopter made data runs over the desert at various headings, altitudes and airspeeds. The data obtained indicate that multipath severity varies directly with the distance from the transmitting site. Signal nulls recorded when the helicopter was 16 miles from the site were 7 dB. At a range of 32 miles, the nulls were 15 dB.

(C) Additional testing and analysis revealed that the received signals would be adequate for the remotely piloted helicopter flights to the extended range. The minimum discernible signal (MDS) of the Angel Peak relay is -106 dBm. The normal received telemetry signal was -81 dBm, and the multipath signal was -95 dBm. Even under the worse case conditions of multipath, the signal is 11 dB above MDS.

2.2.5 Long Range Television Relay Test

(C) The range configuration at Nellis limited helicopter flights to a distance of 40 miles from the Grand View relay site. The television antenna and transmitter were removed from the NITE GAZELLE helicopter and installed on Mount Irish. This location provided a 100 mile transmission distance. Qualitative and quantitative tests demonstrated that the Grand View can successfully relay TV pictures over a 100 mile path with no degradation of picture quality.

2.2.6 Extended Range Helicopter Flights

(C) Two extended range flights in the relay mode were attempted. Severe interference was encountered on the first attempt. The television picture was distorted, the telemetry signal contained dropouts, and the command control carrier was lost. The flight was made under direct control to within two miles of the forty mile limit while the relay performance was being evaluated.

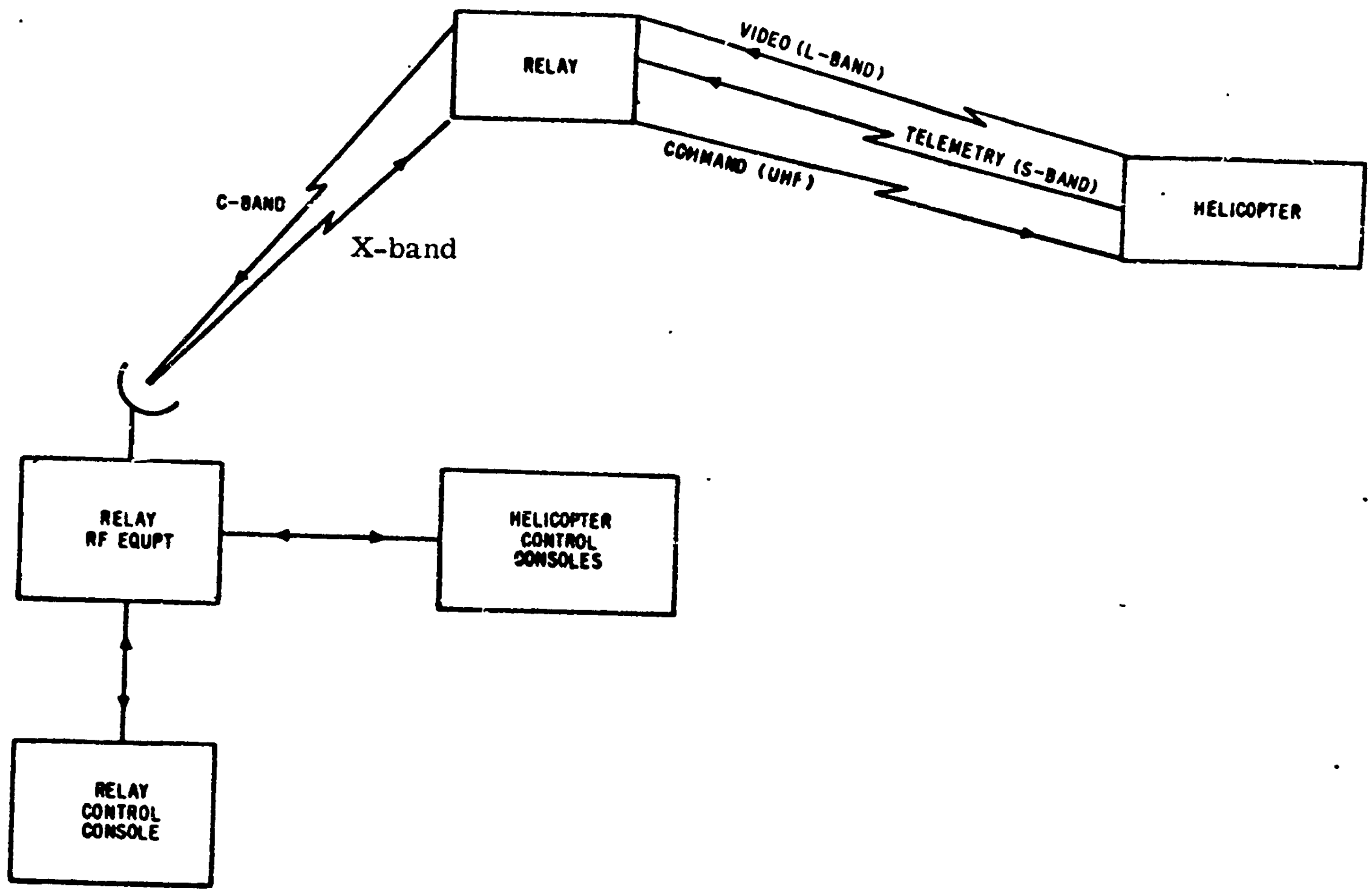
(C) The second flight was attempted on the following day and the interference was so bad, the extended range flight was cancelled. The Grand View system was thoroughly tested and examined for failed components or performance degradation. No problems were found.

(C) Interference on the telemetry frequency had been observed during this test program. Prior to these tests, and after the successful command tests, a VHF relay, radiating several hundred watts on a frequency near the Grand View, was installed at the Angel Peak site. Since no Grand View equipment problems were located, it is assumed that this interference caused the command carrier loss. Time was not available to complete this investigation.

3.0 SYSTEM DESCRIPTION

(C) The Grand View Relay System consists of a relay station and a ground control station. The ground station converts the UHF helicopter commands to X-band and transmits them to the relay station. Telemetry and TV signals are received on C-band, converted back to S and L-band, and sent to the helicopter control console. The airborne station receives the X-band signal from the ground control station, converts it to UHF, and transmits it to the helicopter. Television and telemetry signals from the helicopter are received by the relay station, converted to C-band, and transmitted to the ground station. A block diagram of the system is shown in Figure ?

(C) The system was designed for operation from a high altitude balloon. At Nellis, the airborne portion of the system was installed on Angel Peak.



Grand View System Configuration

Figure 3

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(U) The main objectives of this program were:

1. To evaluate the compatibility of the Grand View and NITE GAZELLE.

2. To develop operational procedures to permit the flight controller to assume control of the helicopter through the use of Grand View.

3. To evaluate the capability of the system to provide continuous two-way RF relay of control and data links.

4. To verify the extended range capability of Grand View.

4.2 Test Plan

(C) Grand View testing was accomplished with the airborne portion of the system installed on Angel Peak. This location is approximately 16 miles from, and approximately 6,000 feet higher than, the Nellis test area.

(C) Interface compatibility tests were completed with the helicopter on the launch pad, engine running, and all controls routed from the NITE GAZELLE ground station through the Grand View Relay System. When testing verified that all command, telemetry and television signals were correctly relayed, the system was declared ready for helicopter flight tests.

(C) The helicopter was started and lift-off was completed in the direct control mode. Transfer to relay mode was accomplished at many ranges, altitudes and headings. Control was transferred to the direct mode for landings.

(C) The helicopter was flown on many different flight paths, altitudes and airspeeds to verify the relay operation. Command signals were relayed through Grand View and helicopter response data were relayed to the ground control station. Sensor information was relayed through Grand View for presentation on the flight controller's console. Signal strength of the TV and telemetry signals was recorded and compared with calculated signal levels.

(U) The Nellis test area is shown in Figure 4. Detailed test plans, objectives and results are presented in Appendix C.

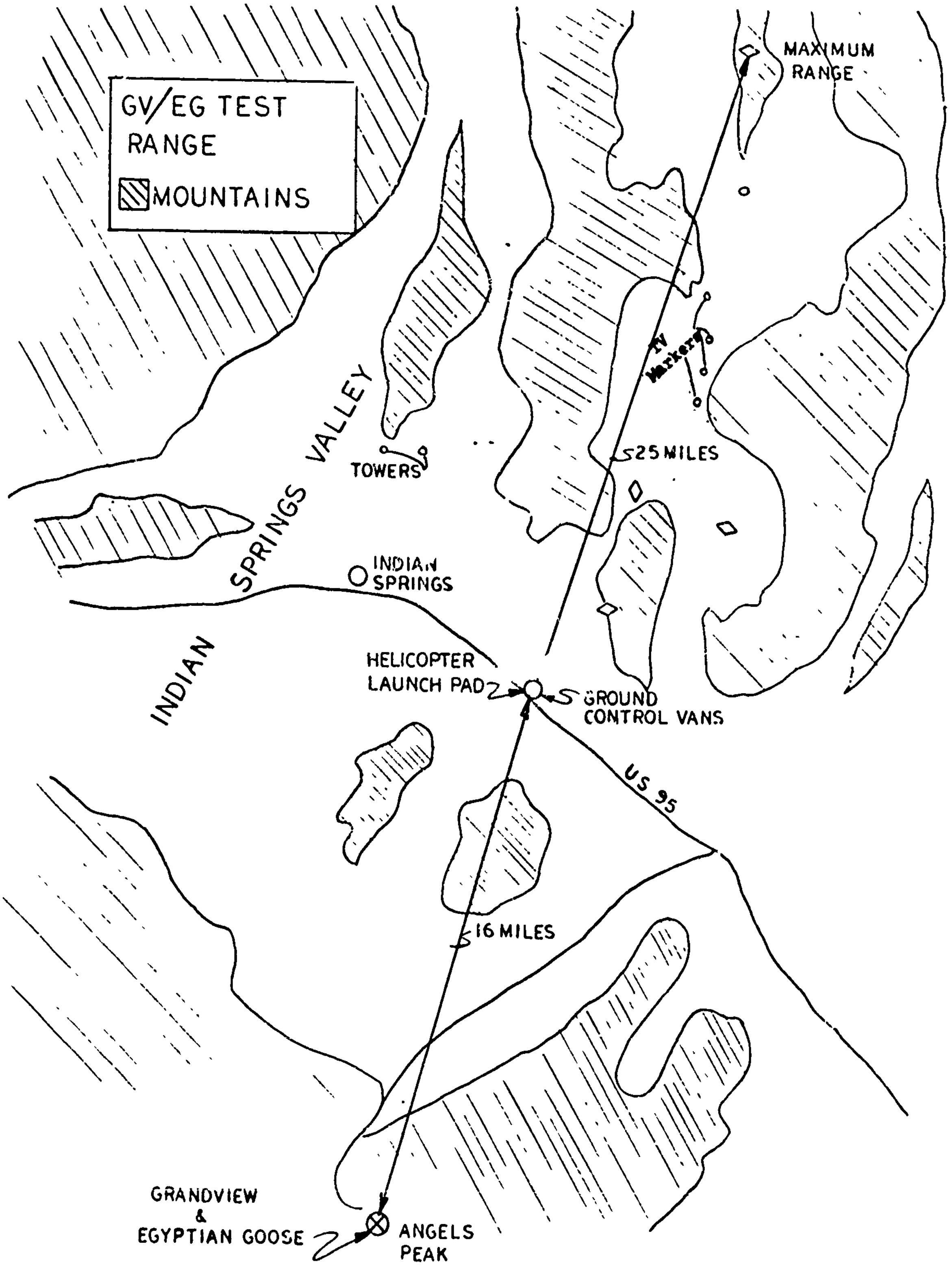

GV/EG TEST
RANGE
MOUNTAINS
MAXIMUM
RANGE
TV
Markers
25 MILES
TOWERS
INDIAN SPRINGS VALLEY
INDIAN
SPRINGS
HELICOPTER
LAUNCH PAD
GROUND
CONTROL VANS
US 95
16 MILES
GRANDVIEW
&
EGYPTIAN GOOSE
ANGELS
PEAK

Figure 4

5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the areas of:

NITE GAZELLE and Grand View Equipment Compatibility
Grand View Control Capability
Grand View Extended Range Performance
Ground Station Performance

5.1 NITE GAZELLE and Grand View Equipment Compatibility

5.1.1 Conclusion

(C) Tests were started with the systems wired together and then progressed to full flight operations. After initial problems were resolved, no further equipment interface problems were detected. The systems were compatible in all respects.

5.1.2 Recommendation

(U) None

5.2 Grand View Control Capability

5.2.1 Conclusion

(C) After television and telemetry signals were successfully relayed through Grand View, command signals were relayed through the system. All flight commands were monitored and the helicopter responded to all of them. Successful command operation was demonstrated on flights over the desert floor.

5.2.2 Recommendation

(U) The Grand View Relay System should be used, as required, to extend the tactical range of the NITE GAZELLE helicopter.

5.3 Grand View Extended Range Performance

5.3.1 Conclusion

(C) Long range tests in Florida and at Nellis proved that the relay is capable of relaying signals transmitted over a distance of 100 miles without degradation. Helicopter testing at extended ranges was hampered by interference on the command and telemetry frequencies. A detailed investigation of the Grand View equipment failed to identify any deficiencies.

5.3.2 Recommendation

(C) Additional tests should be conducted to determine the extent of interference on system performance, and to evaluate the susceptibility of the equipment to jamming.

5.4 Ground Station Performance

5.4.1 Conclusion

(U) The ground station operated successfully throughout the test program.

5.4.2 Recommendation

(U) The ground station should be used, as required.

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ARPA/RML Undated

GLOSSARY

AEC	Atomic Energy Commission
DAME	Distance and Azimuth Measuring Equipment
FAA	Federal Aviation Agency
GCA	Gyrodyne Company of America
IF	Intermediate Frequency
KVA	Kilovolt - ampere
MDS	Minimum Discernible Signal
RF	Radio Frequency
RMS	Root Mean Square
TLM	Telemetry

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(C) The system under test consisted of an airborne relay system designed to extend the control range of the NITE GAZELLE helicopters from twenty to one hundred miles. It has the capability of simultaneously relaying television, telemetry and command signals of five helicopters. The system was designated as the Grand View Relay System.

(U) A block diagram of the airborne portion of the system is shown in Figure A-1.

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE Remotely Piloted Helicopter is a modified counter-rotating, double-bladed helicopter which was originally developed by the U.S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding an 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. For Grand View testing, a quadrature high gain L-band antenna was installed on the helicopter.

2.2 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and a fire control position for target acquisition and optical fire control capability.

(C) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data are sent to the ground via an S-band link, and TV imagery is transmitted to the ground via an L-band link. The effective range of these signals is extended through the use of the Grand View Relay System.

(C) The remote controller has a clear view of the helicopter, as it sits on the pad, through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communication relay system, permits operations beyond ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

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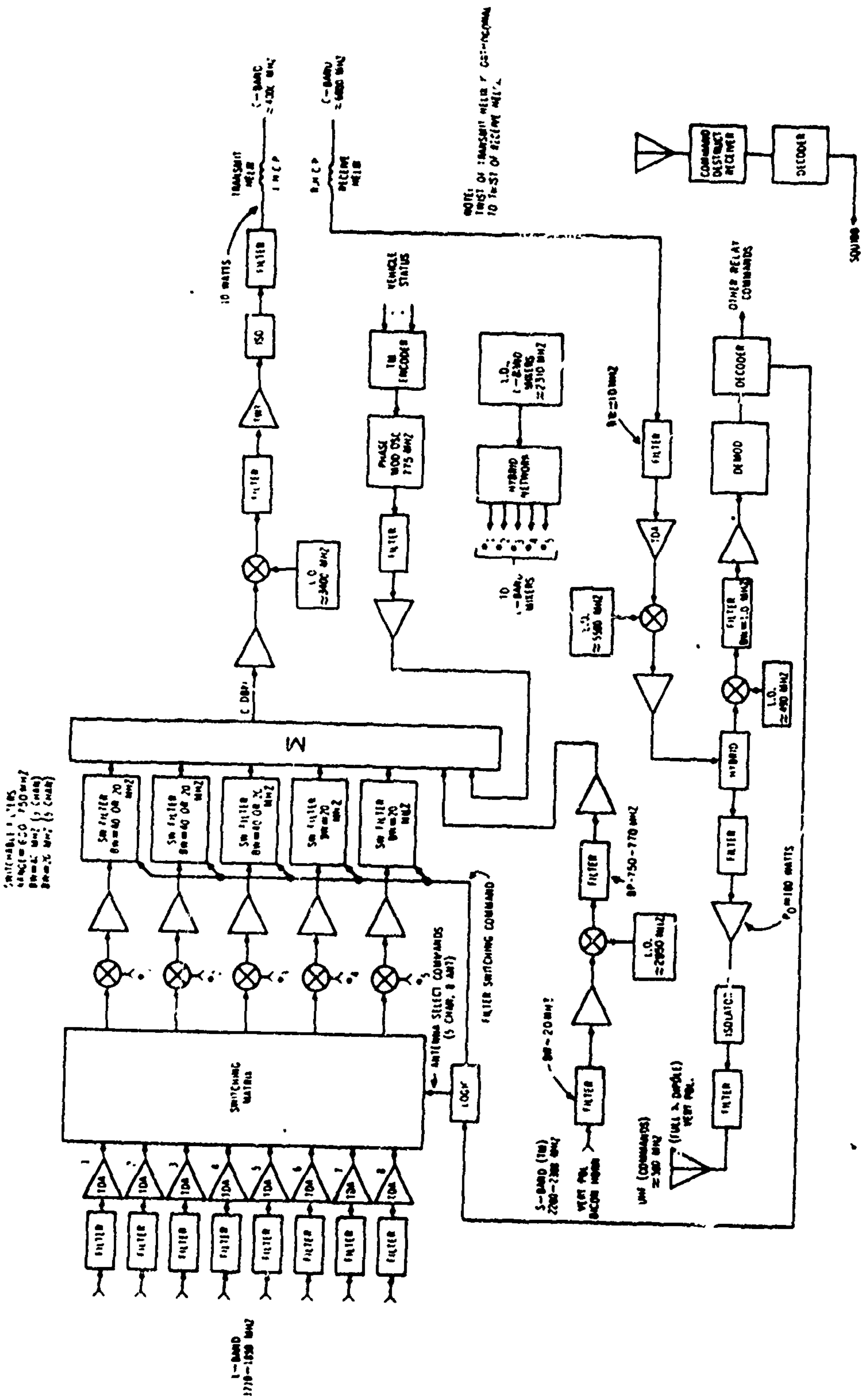

Relay Block Diagram

Figure A-1

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(U) The weapon or sensor controller monitors the surveillance tracking and controls the mount while viewing TV video. He controls the TV camera zoom lens, the 16 mm film camera, and transmits the signals for weapon and sensor operation.

2.3 Grand View Ground Control Station

(U) The Grand View ground control system is located in a portable trailer type van. The control station consists of two consoles, a distribution panel, two antennas and a storage area.

(C) The C-band antenna at the ground control station is a dish, 3 feet in diameter with a linear polarized feed. The unit is mounted on a tripod and swivel which allows manual positioning over a hemisphere.

(C) The X-band antenna, 3 feet in diameter and mounted with the C-band antenna, is a stripline unit of eight biconical dipoles which are fed in parallel by an impedance divider network. The stripline is a standard printed circuit board made of teflon bonded fiber glass. The board is 42" x 5" and 1/8 inch thick when sandwiched on the circuit. Two aluminum sheets are used as cover plates for the stripline.

2.4 NITE GAZELLE/Grand View Relay System

(C) When the relay system is used, the helicopter is launched by the flight controller in the NITE GAZELLE control van while under his visual observation. With the vehicle airborne, the control and data links are switched from direct to the relay mode at the controller's discretion. To do this the helicopter is commanded into the hover mode and control is then switched by a push button selection. With control now through the relay system, the helicopter is commanded out of hover by the controller and the mission proceeds. At this time, all three aircraft communication links, command, telemetry and television, will be operating through the Grand View system.

(C) Landing of the aircraft is accomplished by the controller in the NITE GAZELLE van while in visual contact with the aircraft and after control has been switched from the Grand View to the direct mode of operation.

2.4.1 Television Relay

(C) The L-band antennas completely cover the 360 degree azimuth, and each independently receives signals from any or all of the helicopters that are in its field of view. Each antenna has an associated bandpass filter to pass the L-band signals from all helicopters and a low noise transistor to establish the receiving system noise temperature. The low noise amplifier outputs feed into a switching matrix that allows each RF channel to be independently connected to any antenna. The five channels are then mixed with a common local oscillator to produce a UHF intermediate frequency. The intermediate

frequency (IF) is different for each of the five channels because their L-band frequencies are different. Associated with each channel is a UHF amplifier and a tuned filter that accepts that channel and rejects the others. These filters are selected on the ground before the aircraft is deployed on the basis of the relay channels allocated. The five filters each have a nominal bandwidth of 20 MHz for the accommodation of five nighttime channels. Three of them, however, are switchable to 40 MHz wide filters to accommodate the three 40 MHz wide daytime channels. This switching is done by command, X-band from the ground. The multiple video intermediate frequencies are then summed together linearly, again amplified and converted to the C-band frequency used for the link from the Grand View station to the ground. After amplification, the C-band signal is transmitted to the ground using a low gain spiral antenna. Orthogonal circular polarization is used for the two C and X-band up and down links to reduce the filter requirements. The received C-band signals are down-converted, after amplification, to an IF. This IF (600 to 750 MHz) for convenience is the same as the IF used in the relay and for the L-band signals from the helicopters. These signals are separated from other signals on the C-band downlink, amplified and then converted back to the same L-band signal frequencies which were received by the relay from the helicopter. These L-band signals are then fed into the L-band video receivers of the helicopter control consoles. A coaxial switch is provided to allow the control console to work either with signals received via the relay or directly for short range operation.

2.4.2 Telemetry Relay

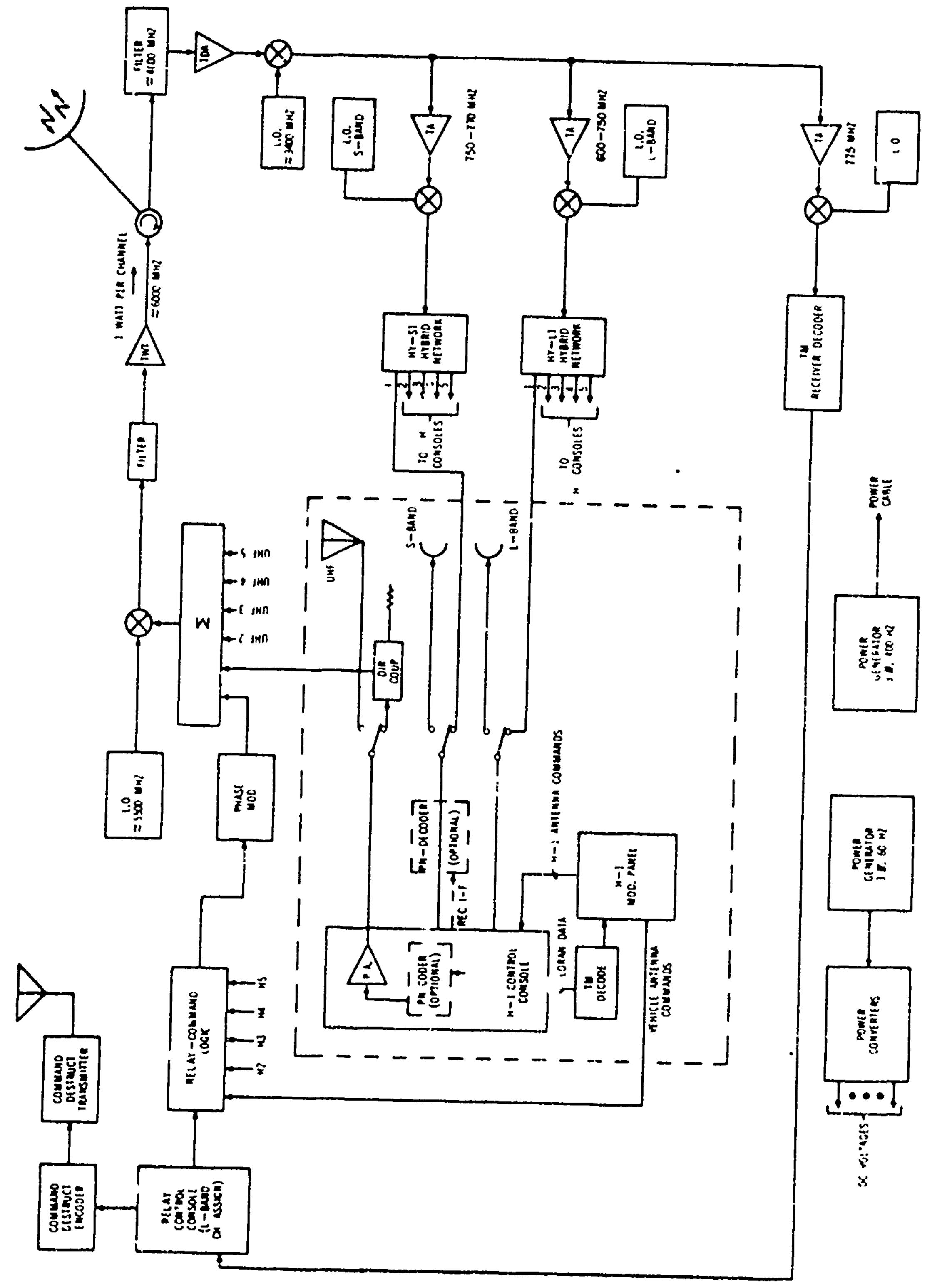
(C) The S-band telemetry signals from the helicopter are all received on the S-band omnidirectional antenna. These are then amplified and converted to an IF in the range of 750 to 770 MHz. This 20 MHz range can accommodate up to at least 25 helicopter telemetry channels, providing they are on adjacent frequencies as indicated previously. This 750 to 770 MHz IF is summed with the video intermediate frequencies and converted to C-band along with the video signals.

(C) On the ground, the 750 to 770 MHz signals at IF are separated and converted back to S-band in the same way as was done for the video signals.

(C) Also, using the same C-band downlink are telemetry signals from Grand View which are used to monitor the condition of the electronic equipment and any other parameters of interest associated with the relay station.

2.4.3 Command Relay

(C) The command link, Figure A-2, "Five Channel Ground Equipment Block Diagram", shows the UHF command signals from the five helicopter control consoles. In the relay mode, they are fed at appropriate levels into a summer and then are converted to a suitable X-band frequency for transmission to the relay. In the relay, these signals, after amplification, are



5-Channel Ground Equipment Block Diagram

Figure A-2

converted back to their original UHF frequencies. These are amplified and then radiated to the helicopters. The power amplifier for this purpose has a 100 watt RMS power handling capability. This high power capability is needed because with multiple signals, an intermodulation problem could develop between the RF carriers. In addition, sufficient power handling capability should be available to handle up to 25 channels for future system expansion.

(C) The bandwidth of these circuits will be about 10 MHz, or sufficient to handle up to 25 continuous channels.

(C) The C-band uplink will also share the Grand View command link. This link is summed with the helicopter command channels, and separated in the relay station and decoded there. The commands that are carried by this channel are the selection of the video IF filters, for day and night type operation, and the selection of the antennas which are connected to each of the five video channels.

(U) At Nellis, the relay station was installed on Angel Peak. This location is 6,000 feet above and 16 miles from the helicopter launch area. A special test was conducted from Mount Irish to Angel Peak to evaluate TV transmission over a 100 mile distance. The Nellis configuration limited other tests to a range of 40 miles.

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified/Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR GRAND VIEW

Date	Test No.	Plan	Comments
6/18/70	149	Antenna Evaluation	Operation of antenna was satisfactory. TV performance was marginal because of limited altitude above pad. Aircraft performance was good.
6/19/70	150	Equipment and Antenna Evaluation	TV performance was good with the increase of altitude in direct mode. Antenna switch incorrectly wired. Switch positions were rewired after test.
6/25/70	-	Frequency Test	No interference was observed and Grand View frequencies were approved for operational use.
7/20/70	151	Operational Test on C, X, and L-band	Evaluation of transmission and reception indicates design is reasonable and functional. Frequent signal dropouts. Ground tests will be scheduled to ascertain if there is a problem in the TV antenna switch.
7/23/70	152	Evaluate direct and relayed telemetry signal	TV signal strength measured at Angel Peak was -45 dBm. Telemetry signal strength was -75 dBm. Antenna switch checked OK after modification.

Table B-1 Continued

Date	Test No.	Plan	Comments
7/23/70	152	Evaluate TV and telemetry for extended range	Data were received from the four antennas. TV signal strength was -45 dBm at 123 degrees, and telemetry strength was -77 dBm. Both measurements were close to predicted levels. Direct TV and telemetry were good. Multipath interference observed on relayed TV and telemetry data.
8/3/70	204	Demonstration	System operation was satisfactory.
8/5/70	206	Demonstration	Flight was unsuccessful because of antenna switch problems.
8/14/70	-	Evaluate extended range TV relay	Satisfactory pictures were received from a distance of 100 miles.
11/24/70	154	Equipment Evaluation	All systems were checked out on the pad. Some intermittent command signals were noted.
11/25/70	154	Equipment Evaluation	The command problem was solved. All systems were satisfactory.
12/9/70	-	Evaluate extended range TV relay	Received signal strength levels agree within 5 db of predicted.
12/10/70	155	Determine best flight path to receive continuous signal.	Altitude was 1000 feet at 330° T. Good TV - no dropouts. Interference observed at 042° and 063°. Control Van #2 received direct data for comparative analysis. Fade margin at Angel Peak was measured as 26 dB.
12/10/70	155	Determine best flight path to receive continuous signal.	All systems were operational with good data received. Interference observed at 041° and 038° on 330° T heading.
12/10/70	155	Determine best flight path for signal.	No interference was observed. All systems worked well. Altitude increased 500 feet.

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Table B-1 Continued

Date	Test No.	Plan	Comments
12/10/70	155	Determine best flight path for signal	Data coverage was 100%. No dropouts. No interference except from a 2265.5 MHz signal.
12/10/70	155	Determine best flight path for signal	Range decreased 1100 yards. Telemetry loss at 043°. Interference observed at 2265.5 MHz.
12/11/70	155	Determine best flight path for signal	Range increased 1100 feet to 5100 yards. Good data received. No data dropouts. Interference still exists at 2265.5 MHz.
12/11/70	155	Determine best flight path for signal	All systems worked well except TV on the direct link. Interference observed on 2265.5 MHz.
12/11/70	155	Determine best flight path for signal	Signal dropouts observed at approximately 6° increments. Comparison signals plotted to determine trouble. Altitude decreased 500 feet.
12/11/70	155	Determine best flight path for signal	Direct signal reception was satisfactory. Dropouts were observed on relayed signal.
12/14/70	156	Determine signal leakage	Command receiver affected by stray RF. Command decoder not effected by this signal at a range greater than 4000 yards.
12/15/70	156	Evaluate full relay mode	TV and command signals were relayed through Grand View for 48 minutes. Signal strength at Angel Peak varied from -80 dBm to -100 dBm. Helicopter flown in full relay mode for a total of 7 minutes.
12/15/70	157	Evaluate full remote control of helicopter	Interference disappeared after the reflector at Angel Peak was aligned. Good flight in full relay mode. No interference until altitude of aircraft decreased to 1400 feet.

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Table B-1 Continued

Date	Test No.	Plan	Comments
12/16/70	157	Evaluate full remote control of helicopter	Angel Peak substituted an L-band antenna to improve signal strength and reduce effects of interfering AEC S-band signal. There was no interference during test. Strong winds aloft terminated test.
9/13/71	Check Flt.	Evaluate TV and telemetry	Cancelled prior to flight for various reasons.
9/15/71	340	Evaluate telemetry and TV	Cancelled prior to flight due to low oil pressure on aircraft.
9/16/71	-	Evaluate telemetry and TV	Aborted in flight due to poor yaw axis response. The lower blades were raised 1/2 turn for better torque neutral.
9/16/71	340	Evaluate TV and telemetry	Aborted in flight because the Vega antenna did not lock up.
9/16/71	340	Evaluate TV and telemetry	This flight was successful. Hand over from direct control to Grand View relay was accomplished at 3500 yards and checked out to 6500 yards.
9/17/71	340A	Telemetry/TV equipment check	Data runs completed without Grand View relay. TV recognition quality poor at full zoom due to mount vibration. Telemetry/TV received signal levels at Angel Peak indicate adequate power reserve budget for 40 miles maximum range. Telemetry signal had maximum variation of 30 dB.
9/17/71	343	Telemetry/TV equipment check	Data runs completed without relay from Angel Peak out to 28 miles from Angel Peak. TV markers were too small to locate and identify at 1500' altitude.

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Table B-1 Continued

Date	Test No.	Plan	Comments
9/21/71	342	Multipath Evaluation	This test was conducted with a manned helicopter. Signal was determined to be adequate for unmanned flights to the maximum range.
9/22/71	343 & 347	Mid/max range flights	Two flights were aborted due to no beacon returns. Transponder was checked by Westinghouse, but no problem was detected.
9/23/71	341	Range limits flight	No data runs were flown due to lack of DAME. DAME was not operational for flight due to misadjustment of helicopter DAME. Helicopter TV driver failed at lift-off plus seven minutes and was replaced post test.
9/24/71	341A	Range limits flight	Hand over to Grand View was accomplished.
9/24/71	341A	Control Jeep Evaluation	Jeep control of the helicopter was satisfactory.
9/26/71	343 & 347	Telemetry/TV equipment check and G.V. max range	Cancelled prior to flight because the relay link video was not operational.
10/18/71	345 & 346	Radar beacon evaluation extended range and G.V. mid range check	Cancelled prior to flight due to heavy snow.
10/22/71	346 & 347	G.V. mid range and max range flight	Marked two towers, then cancelled test since Egyptian Goose beacon was not working due to a faulty connection on aircraft.
10/26/71	347	Max range flight	Cancelled prior to flight test due to scan converter problems and poor video.

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Table B-1 Continued

Date	Test No.	Plan	Comments
11/3/71	347	Max range flight	The test was cancelled when aircraft telemetry and TV data were lost.
11/9/71	343	Mid range flight	TV and telemetry were placed in relay mode at 6000 yards. Beacon checks indicate the beacon antenna should be relocated.
11/10/71	-	Evaluate beacon	Flight checks demonstrated satisfactory beacon performance.
11/11/71	343 & 347	Mid and max range flight	Poor TV and telemetry in the relay mode. Aircraft flown to within 2 miles of maximum range target in direct mode.
11/12/71	343 & 347	Mid and max range flight	Egyptian Goose equipment not ready, max range test cancelled. A short range flight was flown in the relay mode. Severe telemetry noise was observed.

APPENDIX C

FLIGHT TEST DATA FOR GRAND VIEW

(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

ANTENNA EVALUATION
Flight No. 1 Test No. 149
18 June 1970

(C) This test was conducted to evaluate the newly installed Grand View antenna aboard helicopter DS-1745. The distance from the aircraft to the Grand View installation on Angel Peak was 16 miles. The helicopter hovered over the pad at an altitude of 200 feet and 1,000 feet from the pad. The antenna deployed as the helicopter lifted off the pad and stowed correctly when the helicopter landed. TV performance was poor because of the limited altitude of the aircraft above the pad. Aircraft performance was good and the stability in flight was good. Flight time was twenty-five minutes.

ANTENNA EVALUATION
Flight No. 2 Test No. 150
19 June 1970

(C) This test was conducted with the helicopter in a hover at an altitude of 500 feet, to perform antenna checks. The TV worked well in the direct mode, however, it was poor in the relay mode. An incorrectly wired antenna switch caused poor relay TV. This problem was corrected after the test by rewiring the switch position as follows:

Switch Position	Function
1	Forward
2	Starboard
3	Aft
4	Port

Flight duration was thirty minutes.

FREQUENCY TEST
Flight No. - Test No. -
25 June 1970

(C) This test was conducted to determine if the Grand View transmitter located on Angel Peak created interference on any airline frequencies. The test was coordinated with:

1. Western Frequency Coordinator
2. AEC Frequency Coordinator
3. HQ Frequency Coordinator
4. Western Regional FAA Frequency Manager, Los Angeles, Calif.
5. FAA Maintenance Liaison Officer.

At the end of the broadcasting day, all agencies confirmed no interference due to Grand View transmission. This test was very important to prove that the operation of the Grand View would not violate or interfere with any electronic communication or operation conducted by any commercial airline in operation.

EQUIPMENT EVALUATION
Flight No. 3 Test No. 151
20 July 1970

(C) This test was conducted to evaluate the transmission and reception of C, X, and L-band signals in direct and relay modes of the helicopter through the Grand View relay system, and to ascertain which quadrant of TV antenna was best. The helicopter hovered over the pad at a low altitude while the relay reception was evaluated. After a satisfactory check, altitude was increased to 1,000 feet and the aircraft started an evaluation run on a heading of 027 degrees. A square pattern was flown at an altitude of 1,000 feet and a ground speed of 30 knots. The direct and relay comparisons of TV indicate the Grand View design objectives are reasonable and can be met. Telemetry data received directly from the helicopter at the control van were good, but the relayed data contained several signal dropouts. The quadrant antenna switch installed on the helicopter was suspected, and proved after testing, to be faulty and was replaced post-test. Ground tests were scheduled to investigate signal dropouts. Flight time was sixty-three minutes.

ANTENNA EVALUATION
Flight No. 4 Test No. 152
23 July 1970

(C) This test was conducted in the pad area with the helicopter at an

altitude of 150 feet for the purpose of evaluating antenna operation through a 360° rotation in increments of 6 degrees. The Angel Peak installation is 16 miles, slant range from the flight pad. Maximum signal strength measured at Angel Peak was -45 dBm on the TV link. This compared to the -44 dBm that was predicted. The maximum telemetry signal strength was -75 dBm. Telemetry broke lock at -64 dBm before the expected -78 dBm. The cause of the break was not determined. Flight time was twenty minutes.

EQUIPMENT EVALUATION
Flight No. 5 Test No. 152
23 July 1970

(C) This test was conducted to verify and evaluate the performance of the TV and helicopter telemetry prior to committing the aircraft to extended range operation. Flight altitude was 1,000 feet and airspeed varied from 35 to 55 knots. The helicopter started transmitting data from the first antenna, then continued through each of the four antennas. Telemetry signal strength as measured at Angel Peak at the start of run 2 on a helicopter heading of 123 degrees was -77 dBm, and the TV signal level was -45 dBm. A few dropouts were noted on the relayed signal. Multipath interference was observed on both signals. The telemetry and TV signal dropouts were more numerous on the 303 degree run. Signals at Angel Peak were received on antenna #1 for the 123 degree run and antenna #7 was used on the 303 degree run. There were no dropouts observed on the direct TV and telemetry signals. Flight time was thirty-five minutes.

DEMONSTRATION FLIGHT
Flight No. 6 Test No. 204
3 August 1970

(C) This test was conducted to compare TV and telemetry signals received through the Grand View relay system with those received direct from the helicopter. Flight altitude was 1,000 feet and ground speed was 20 knots. The helicopter left the pad area on a heading of 015 degrees, flew approximately 4 miles, a turn was made to 127 degrees and the helicopter continued on this heading for approximately 4 miles. Return to the pad area was made on a heading of 290 degrees. Different helicopter antennas were selected to provide maximum signal levels during the flight. Numerous TV and telemetry dropouts were observed on all headings. Telemetry signal dropouts were momentary, but the TV dropouts varied in duration. The TV transmitter power output was down 9 db. Minimum observed telemetry signal strength was -90 dBm. Flight time was twenty-eight minutes.

DEMONSTRATION FLIGHT
Flight No. 7 Test No. 206
5 August 1970

(C) This test was conducted to collect signal strength data to continue the comparison of telemetry and TV performance in the relay and direct modes. Flight altitude was 1,000 feet and airspeed was 30 knots. The TV antenna switch developed problems shortly after lift-off and the helicopter landed for repairs. Another flight was attempted and the same problems were observed. The relay mode of operation was unsuccessful. Flight time was twenty-nine minutes.

EXTENDED RANGE TEST
Flight No. - Test No. -
14 August 1970

(U) This test was conducted to determine the quality of the TV picture transmitted from Mount Irish to Angel Peak and relayed to the ground station at Nellis AFB. The television camera, transmitter and antenna were removed from helicopter 1745 and installed on Mount Irish, approximately 100 miles from Angel Peak. An excellent quality picture (subjective evaluation) was obtained at the ground station at Nellis. Additional tests to obtain quantitative data are planned.

EQUIPMENT EVALUATION
Flight No. - Test No. 154
24 November 1970

(U) This test was conducted on the pad to evaluate the performance of all systems after major maintenance was completed. The engine was started and the command transmitter number 1 was disabled. Command transmitter number 2 performed all command functions. The helicopter was placed in the memory mode and all controls were switched through the Grand View Relay System. Intermittent command signals were noted, but all controls were responsive. The systems were adjusted for optimum operation.

EQUIPMENT EVALUATION
Flight No. - Test No. 154
25 November 1970

(U) This test was conducted on the pad with the helicopter engine running to continue equipment checks. The command problems noted on the previous

test were caused by VHF transmitter interference. The relayed telemetry and TV signals were poor because of the antenna location while the helicopter was on the pad.

EXTENDED RANGE TEST
Flight No. - Test No. -
9 December 1970

(U) This test was conducted to obtain quantitative data for the performance of the Grand View Relay System over a distance of 100 miles. Subjectively, the relayed TV pictures were rated as excellent when compared to a standard test pattern received from a camera connected directly to the receiver. Quantitative test results are summarized in the following table.

TABLE C-1 (Unclassified)

SUMMARY OF EXTENDED RANGE TEST

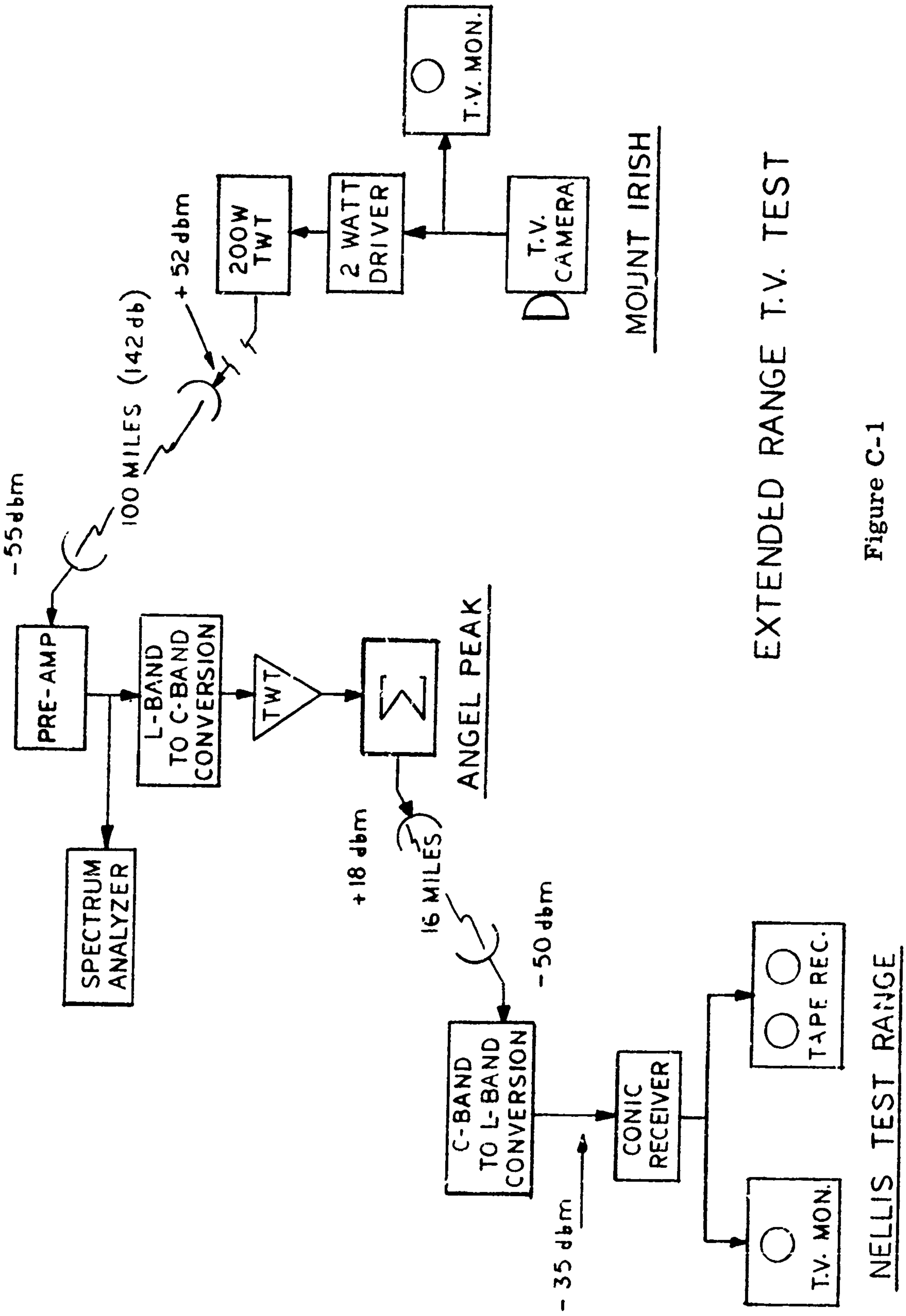
Expected Receive Level	-55 dBm
Normalized Maximum Measured Receive Level	-59 dBm
Normalized Signal Variation with Antenna Elevation	-60 to -64 dBm (15' elevation intervals)

Fade Margin	Normalized Level (dBm)	Margin (dB) Maximum	Minimum
First Noise Detected	-74	15	10
Noicy But Useable	-78	19	14
Barely Detectable Picture	-79	20	15

The test set up is shown on the following page.

EQUIPMENT EVALUATION
Flight No. 8 Test No. 155
10 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak when the helicopter is flying at an altitude of 1,000 feet. Airspeed varied from 30 to 45 knots and the run was made on a heading of 330° T at a distance of 5100 yards from the pad. The port TV quadrant antenna was used during the data run. Direct telemetry data recorded in the control van was solid throughout the run. The relayed telemetry signal strength measured -76 to -88 dBm with the aircraft on the pad, -76 to -78 dBm during the data run, and -76 to -90 dBm when the helicopter was



EXTENDED RANGE T.V. TEST

Figure C-1

returned to the pad. Dropouts, but no carrier losses, were noted between 042° and 063°. The fade margin at Angel Peak was measured at 26dB. There were no TV signal problems. Minimum recorded signal strength was -36 dBm and the threshold was -62 dBm. It is believed that multipath created as a result of the irregular terrain between operational area and Angel Peak caused the telemetry signal problems. Flight time was thirty-eight minutes.

EQUIPMENT EVALUATION
Flight No. 9 Test No. 155
10 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,000 feet. The flight path was at a range of 5100 yards from the pad and helicopter heading was 330° T. Airspeed was 30 knots. The port antenna on the helicopter was used during this run. There was no reduction in the level of recorded telemetry signal strength, but a reduction in quality was noticed at 041° through 018°. The presence of an interfering signal operating at 2265.5 MHz is suspected as the cause of the telemetry signal problems. The interference was received at Angel Peak only, and was found when direct and relayed telemetry signals were compared on a spectrum analyzer. Flight time was twenty-five minutes.

EQUIPMENT EVALUATION
Flight No. 10 Test No. 155
10 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,500 feet. Airspeed was 30 knots. The flight was conducted with the helicopter on a heading of 330° T at a range of 5100 yards from the pad. The port antenna was selected for the data run. Telemetry and TV signals were solid during the complete run. An interfering signal was present at 2265.5 MHz, but it did not affect the telemetry or TV signals. Flight time was thirteen minutes.

EQUIPMENT EVALUATION
Flight No. 11 Test No. 155
10 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter airspeed is

35 knots at an altitude of 1,500 feet. The run was made on a heading of 330° T at a range of 5100 yards from the pad. The port antenna was selected for this run and solid TV and telemetry signals were provided. Flight time was ten minutes.

EQUIPMENT EVALUATION
Flight No. 12 Test No. 155
10 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,000 feet. Airspeed was 30 knots and the helicopter heading was 330° T at a range of 4000 yards from the pad. The port TV antenna was used for this run. A complete telemetry signal loss occurred on a bearing of 043°. The 2265.5 MHz signal was observed. Flight time was nine minutes.

EQUIPMENT EVALUATION
Flight No. 13 Test No. 155
11 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,500 feet. The run was made with the helicopter on a heading of 330° T, 5100 yards from the pad. Airspeed was 35 knots. The "Big U" mount was set at -30°. The port TV antenna was used on this run. The 2265.5 MHz signal was observed on the relayed telemetry signal, but it did not effect the data. The TV and telemetry signals were solid throughout the data runs. Flight time was thirty-four minutes.

EQUIPMENT EVALUATION
Flight No. 14 Test No. 155
11 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,500 feet. Airspeed was 35 knots. The port TV antenna was used during the data run. The flight path was on a 330° T heading, 5100 yards from the pad. The "Big U" mount was set at -65°. A problem occurred on the direct TV signal link, but the relayed data were satisfactory. The 2265.5 MHz signal was observed but it did not cause any problems. The relayed signals were solid during the complete run. Flight time was eleven minutes.

EQUIPMENT EVALUATION
Flight No. 15 Test No. 155
11 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best relayed signals to Angel Peak. Flight altitude was 1,000 feet and airspeed was 30 knots. The flight path was on a 330° T heading, 5100 yards from the pad area. The first run was cancelled in flight because of helicopter collective problems. Direct signals were solid through the data run. Telemetry signal problems were noted on the following bearings: 014°, 022°, 027°, 034°, 038°, 042°, 048°, and 074°. The port TV antenna was used for the complete flight. The 2265.5 MHz signal was observed. Flight time was twenty minutes.

EQUIPMENT EVALUATION
Flight No. 16 Test No. 155
11 December 1970

(C) This test was conducted to determine the flight path and heading that will provide the best signals to Angel Peak while the helicopter is flying at an altitude of 1,000 feet. Airspeed was 30 knots. The flight path was on a heading of 330° T, 5100 yards from the pad. Telemetry signal dropouts in the relay mode were noted on the following bearings: 14°, 20°, 28°, 32°, 40°, 76° and 82°. TV and telemetry signals received through the direct mode were satisfactory. Flight time was nine minutes.

EQUIPMENT EVALUATION
Flight No. 17 Test No. 156
14 December 1970

(C) This test was conducted to evaluate the command signal leakage from the command transmitter located in the helicopter control van, and to evaluate command receiver sensitivity changes. The flight path was 5100 yards from the pad on a 330° T heading. Airspeed was 30 knots and flight altitude was 1,500 feet. Additional readings were taken while the helicopter was inbound to the pad area. Data were recorded while the helicopter was in the "memory" mode and the command transmitter was radiating into the data link. Three passes were completed and the telemetry data confirmed that command leakage was present. The signal became strong enough to activate command decoders when the helicopter was within a range of 4000 yards at 1,500 feet, and at a 4700 yard range at 1,000 feet. Flight time was thirty-nine minutes.

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EQUIPMENT EVALUATION
Flight No. 18 Test No. 156
15 December 1970

(C) This test was conducted to evaluate the Grand View relay system and aircraft performance while in full relay mode. Flight altitude was 1,500 feet, airspeed was 30 knots and the flight path was on a heading of 330° T, 5100 yards from the pad area. Television signals from the helicopter and command signals to the helicopter were relayed through the Grand View system for a total of forty-eight minutes. The commands given to the helicopter were; a, laser "on" and "off"; b, Hypervelocity Gun "arm", "charge", "fire"; c, mount camera "on" and "off"; d, helicopter turns, speed changes and lateral turns. The telemetry received signal strength measured at Angle Peak varied from -80 dBm to -100 dBm. Some interference was noted from signals on frequencies of 2262.5 and 2257.5 MHz. The helicopter was flown in full relay (command, telemetry and TV) mode for a total of seven minutes This was the time to make one complete pass. Total flight time was seventy-six minutes.

EQUIPMENT EVALUATION
Flight No. 19 Test No. 157
15 December 1970

(C) This test was conducted to evaluate the Grand View relay system and aircraft performance in the full remote mode. Flight altitude was 1,500 feet, airspeed was 35 knots on a flight path 5100 yards from the pad area on a heading of 330° T. The mount was exercised during the run to determine the effect of command signals on the relayed data. Relayed data were satisfactory during the time mount commands were being sent. At the start of the test the two interfering signals were present and the telemetry signal level was down 20 dB with some signal dropouts noted. The Angel Peak antenna was aligned and the signal level increased 20 dB, and the signal dropouts disappeared. This test was conducted in the full relay mode. On the last pass, the helicopter altitude was reduced in 100 foot increments. Dropouts on the relayed signal started when the helicopter reached 1,400 feet. Flight time was eighty-three minutes.

EQUIPMENT EVALUATION
Flight No. 20 Test No. 157
16 December 1970

(C) This test was conducted to evaluate the Grand View Relay System and aircraft performance when operating in the full remote mode. Flight altitude was 1,300 feet, airspeed was 30 knots and the flight path was on a heading of 330° T, 5100 yards from the pad area. An L-band antenna to receive telemetry signals was installed at Angel Peak to minimize the interference caused by

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S-band signals. Although there was a 12 dB loss because of antenna mismatch, the interference on the telemetry signal was reduced. The S-band signals were 30 dB down in this configuration. The next run continued with the same satisfactory results until strong winds aloft terminated the test. Flight time was twenty-five minutes.

EQUIPMENT EVALUATION
Flight No. 21 Test No. -
16 September 1971

(U) This test was conducted to flight check the helicopter after overhaul. The flight was aborted because of poor yaw axis response.

EQUIPMENT EVALUATION
Flight No. 22 Test No. 340
16 September 1971

(U) This test was conducted to evaluate the quality of the signals relayed through the Grand View system while the helicopter is flying over a planned course. The test was cancelled when the Vega antenna would not stay locked. Flight time was eighteen minutes.

EQUIPMENT EVALUATION
Flight No. 23 Test No. 340
16 September 1971

(C) This test was scheduled to continue the evaluation of the Grand View Relay System. Flight altitude was 1,500 feet and airspeed was 45 knots. During the flight the tip brakes developed a problem and caused early flight termination. A hand over to full remote was made at 3500 yards and carried out to 6500 yards. Television video was good, but interference was noted. DAME was not operational and it is a mandatory item for full relay flights. Flight time was twenty-five minutes.

EQUIPMENT EVALUATION
Flight No. 24 Test No. 340A
17 September 1971

(C) This test was conducted to demonstrate the ability of the Grand View system to relay command, TV and telemetry signals. Flight altitude was

1,000 feet and airspeed was 45 knots. The helicopter was flown to an initial position and a square pattern was flown. DAME plotted position information was compared with actual positions. The TV was inoperative for this flight. Telemetry and TV signals received at Angel Peak indicate adequate power reserve for an extended range flight of 40 miles. Flight time was fifty-two minutes.

EQUIPMENT EVALUATION
Flight No. 25 Test No. 343
17 September 1971

(C) This test was conducted to demonstrate the ability of the helicopter TV to recognize navigation markers and to evaluate Egyptian Goose positioning ability. A run was completed, without the relay from Angel Peak, to a range of 28 miles from the Peak site. Signal levels were adequate but the TV markers were too small to locate and identify at 1,500 feet altitude. At full zoom, the TV showed excessive jitter because of tracking mount vibrations. Flight duration was sixty minutes.

MULTIPATH EVALUATION
Flight No. - Test No. 342
21 September 1971

(U) This test was conducted to obtain the data required to evaluate multipath conditions on range 3. The NITE GAZELLE TV transmitter and antenna were mounted on a manned Huey helicopter for this test. The helicopter flew around the inner circumference of the lake bed and hovered to collect data at specified points. Altitude at the data points was varied from 500 to 2,000 feet. After measurements were taken in the dry lake area, the helicopter followed the TV markers out to the range limit. Signal levels obtained at the maximum range indicate that adequate signal will be available to control the NITE GAZELLE helicopter and to receive response data.

EQUIPMENT EVALUATION
Flight No. 26 Test No. 341
23 September 1971

(C) This test was conducted to demonstrate the ability of the Grand View system to relay Command, TV and telemetry signals. The helicopter had a successful avionics check flight, but the fuel solenoid failed and was replaced. These repairs delayed the flight and the remaining time was not adequate to complete the data runs. In flight, a DAME problem was detected and it was repaired after the test.

EQUIPMENT EVALUATION
Flight No. 27 Test No. 341A
24 September 1971

(C) This test was conducted to demonstrate the ability of the Grand View system to relay Command, TV and telemetry signals. Hand over to Grand View relay was accomplished at 7500 yards, and the flight plan completed according to plan. Flight altitude was 1,000 feet and ground speed was maintained at minimum safe at data collection points. Flight time was fifty-nine minutes.

EQUIPMENT EVALUATION
Flight No. 28 Test No. 341A
24 September 1971

(C) This flight was conducted to evaluate the capability of the Jeep Control Station to fly the helicopter. The helicopter was started by the control van, then control was assigned to the Jeep Control Station for take off, maneuvers and landing. The helicopter was under visual flight rules at all times. The jeep was located in the pad area. All systems were satisfactory. Flight time was ten minutes.

EQUIPMENT EVALUATION
Flight No. 29 Test Nos. 346 & 347
22 October 1971

(C) This test was conducted to evaluate the performance of the Grand View system on medium and maximum range flights. Helicopter command and response data were relayed through the Grand View, and helicopter position information was supplied by the Egyptian Goose Radar System. The helicopter beacon was not observed in the Ground Control Station. Since Egyptian Goose position information was mandatory for the extended range flight, the helicopter was brought back to the pad for an equipment check. Another flight was attempted but the beacon signal was not observed. Two towers were marked in the general range area and then the flight was cancelled.

EQUIPMENT EVALUATION
Flight No. 30 Test No. 343
9 November 1971

(C) This test was conducted to evaluate the mid-range operation of the Grand View Relay System. The Egyptian Goose Radar System was used to provide helicopter position information. The telemetry and TV systems were

placed in relay mode 6000 yards from the pad area. Two tower positions were located and plotted. Beacon returns were lost when the helicopter changed headings to approach the towers. Testing indicated that a new beacon antenna installation is required to provide continuous coverage on all aircraft headings. Flight time was sixty minutes.

EQUIPMENT EVALUATION
Flight No. 31 Test No. -
10 November 1971

(C) This test was conducted to evaluate the relocated beacon antenna. The helicopter was flown at 500 and 1,000 feet and various heading changes were made. The relocated beacon antenna provided adequate signals during the complete flight. The flight was made with all systems in the direct control mode.

EQUIPMENT EVALUATION
Flight No. 32 Test Nos. 343 & 347
11 November 1971

(C) This test was conducted to evaluate the mid-range and max-range capability of the Grand View and Egyptian Goose systems. Several attempts were made to use the relay mode, but telemetry dropouts, noise on the telemetry signal, and Command signal losses made it impractical to use this mode. The beacon signal was good so a maximum range flight was attempted in the direct control mode. The loss of the TV zoom capability made it difficult to locate the TV markers, but the flight was continued out to a distance of approximately thirty-nine miles from the Angel Peak site.

EQUIPMENT EVALUATION
Flight No. 33 Test Nos. 343 & 347
12 November 1971

(C) This test was conducted to evaluate the mid-range and max-range capability of the Grand View and Egyptian Goose systems. The Egyptian Goose equipment was not ready when scheduled and the max-range test was cancelled because of range time. A short range flight was flown in the relay mode. Severe telemetry noise and command uplink losses were observed. These problems were the same as those experienced on the 11 November flight. Beacon performance during this flight was good.

11.0 NITE GAZELLE/EGYPTIAN GOOSE RADAR SYSTEM (U)

ABSTRACT

(C) The NITE GAZELLE/Egyptian Goose Radar System was tested at Nellis AFB, Nevada from September 1970 through February 1971, and from September through 12 November 1971. Testing was conducted with the airborne portion of the system installed at Angel Peak. Radar targets were trucks located on the desert floor, the NITE GAZELLE helicopter and aircraft targets of opportunity. Signal strength measurements obtained from 2 1/2 ton truck targets located forty-eight miles from the radar indicated that the system could detect targets when they were located at a distance of 100 miles from the radar. Moving targets were detected at a minimum radial velocity of 4.9 miles per hour. Resolution tests conducted at a range of nineteen miles demonstrated that the system performance met design specifications of 150 feet range resolution and 500 feet azimuth resolution at a radar-to-target range of 50 miles. During the test program the system simultaneously tracked targets and the NITE GAZELLE helicopter. Target and helicopter position information was provided to the flight controller so that the helicopter could be flown to intercept the targets.

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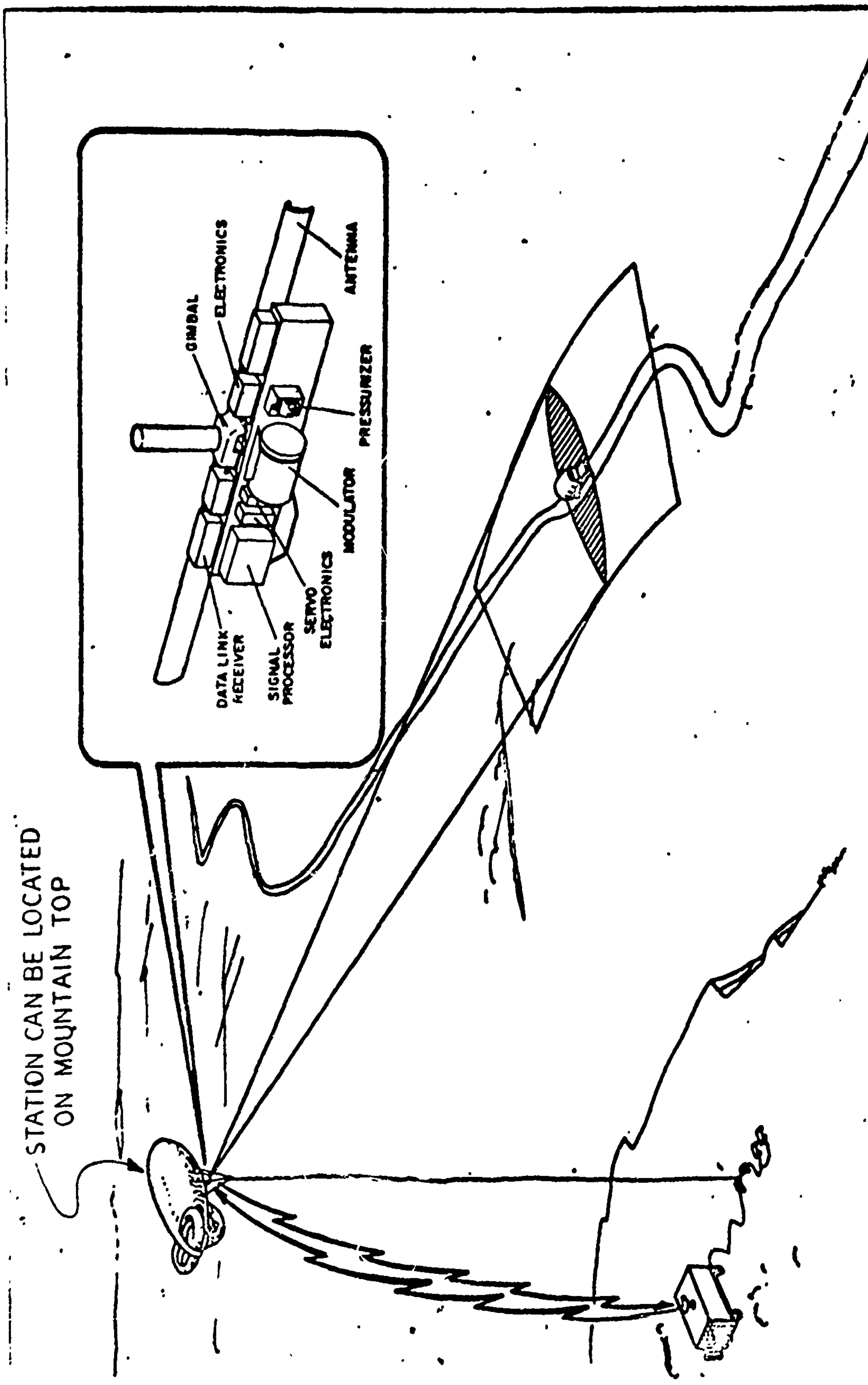

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NITE GAZELLE
EGYPTIAN GOOSE RADAR SYSTEM
Figure 1

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1.0 INTRODUCTION

(C) This program report evaluates the performance of the Egyptian Goose Radar System. The flight test program was conducted at Nellis AFB, Nevada from September 1970 to 12 November 1971. The radar system was used to detect and track ground and airborne targets moving at various speeds and on different headings. During this test period twenty-two tests were supported. Fourteen of these involved the use of the NITE GAZELLE helicopter.

(C) The Egyptian Goose Radar System is one configuration of the ARPA Advanced Standoff Interdiction Weapon and Sensor Systems conceived to counter enemy infiltration along the roads and waterways of Southeast Asia. The remotely piloted NITE GAZELLE helicopter was equipped with sensors to provide real time navigation, target acquisition and optical fire control capability under both day and low light level conditions of night. Weapons were selected to destroy a wide variety of fixed, hard and moving targets. The Egyptian Goose Radar System provides continuous surveillance of specified target areas and presents helicopter and target position information on displays located in the ground station.

(C) The radar target detection capability was demonstrated to be 100 miles for a 2 1/2 ton truck. Range and azimuth resolution was determined to be 150 and 160 feet at a radar range of 19 miles. Range and azimuth accuracies were found to be ±50 yards and ±1.0 degree. These results confirm that design specifications were met.

2.0 RESULTS

2.1 Summary of Results

(C) The results of the Egyptian Goose Radar test program demonstrate that equipment performance met design specifications. At Nellis, the airborne portion of the system was installed on Angel Peak. This location required that control signals to the station and data signals from the relay be transmitted over a distance of sixteen miles. Resolution and accuracy tests were conducted with the Egyptian Goose I configuration. The system was upgraded to an Egyptian Goose II configuration and used to support the extended range helicopter flights. Maximum detection range and minimum detection velocity tests were completed in Florida prior to deployment of the system at Nellis. The Nellis tests indicated that performance continued to be as expected. Range resolution (150 feet) and azimuth resolution (161 feet) performance measurements were obtained from a target array of radar reflectors located nineteen miles from the radar site. Range accuracy (+150 feet) and azimuth accuracy (+1.0°) determinations were obtained by comparing plotted radar position information to the surveyed location of various targets. Because of altitude limitations the 2 1/2 ton truck detection range (100 miles) was obtained by extrapolating data obtained under controlled test conditions at a range of 48 miles. Minimum detectable velocity tests were limited to 4.9 miles per hour. This was a target problem and no indications of radar hardware problems were found that would prevent the system from meeting the 2.0 mile per hour requirement. Table I below, compares achieved performance with design specifications. Appendix B contains a summary of scheduled operations.

TABLE I (Title Unclassified
Table Confidential)

PERFORMANCE SUMMARY VS DESIGN SPECIFICATIONS

Function	EG I Design Specifications	EG II Design Specifications	Performance
Range Resolution	150 feet	100 ft. at .2 μ sec 300 ft. at .6 μ sec	150 feet*
Range Accuracy	--	--	± 150 feet
Azimuth Resolution	± 170 feet*	500 ft. at 50 miles	± 161 feet*
Azimuth Accuracy	--	--	± 1.0°
Minimum Detection Speed	2.8 mph	2.0 mph	4.9 mph
Detection Range 2 1/2 ton truck	50 miles	100 miles	100 miles**
Relay to Ground Station Distance	3 miles	5 miles	16 miles

* Test performance and design specifications for a range of nineteen miles.
** Based on data obtained at a range of 48 miles and an altitude of 7,000 feet.

2.2 Discussion of Test Results

2.2.1 Range and Azimuth Resolution

(C) Four range and four azimuth targets were arranged on the desert floor at a range of nineteen miles from the radar site. The gain of the radar was switched through the four manual modes of operation and the Automatic Gain Control (AGC) mode. Manual modes 2 and 3 produced a range resolution of 150 feet. Manual modes 4 and 7 and the AGC mode resulted in a resolution of 200 feet. Azimuth resolution less than 161 feet was demonstrated in manual modes 2 and 3. From these observations it can be concluded that design specifications for range and azimuth resolution were met.

2.2.2 Range and Azimuth Accuracy

(C) Corner reflectors were placed at various surveyed positions, illuminated by the radar and their position presented on the displays. Differences between surveyed positions and displayed positions show that the system can provide target locations to an accuracy of ±50 yards in range and ±1.0 degrees in azimuth. The displays and operator proficiency are the limiting factors in determining location accuracies.

2.2.3 Detection Range

(C) Detection and tracking tests were conducted using aircraft and trucks. The radar cross section of all targets was known so performance on all type targets could be compared. Radar signal strength measurements obtained at a range of 48 miles were extrapolated to show a 100 mile detection range for a 2 1/2 ton truck. Test range limitations prevented testing at the 100 mile range.

2.2.4 Minimum Detection Speeds

(C) Detection and tracking of ground vehicular traffic were performed in the MTI and map modes of radar operation. Lowest measured velocity radial to the radar was 4.9 miles per hour. Efforts to make runs at the 2 miles per hour design minimum were not made because of target instrumentation problems. During the test program, there were no indications that the minimum detectable velocity would have not been achieved.

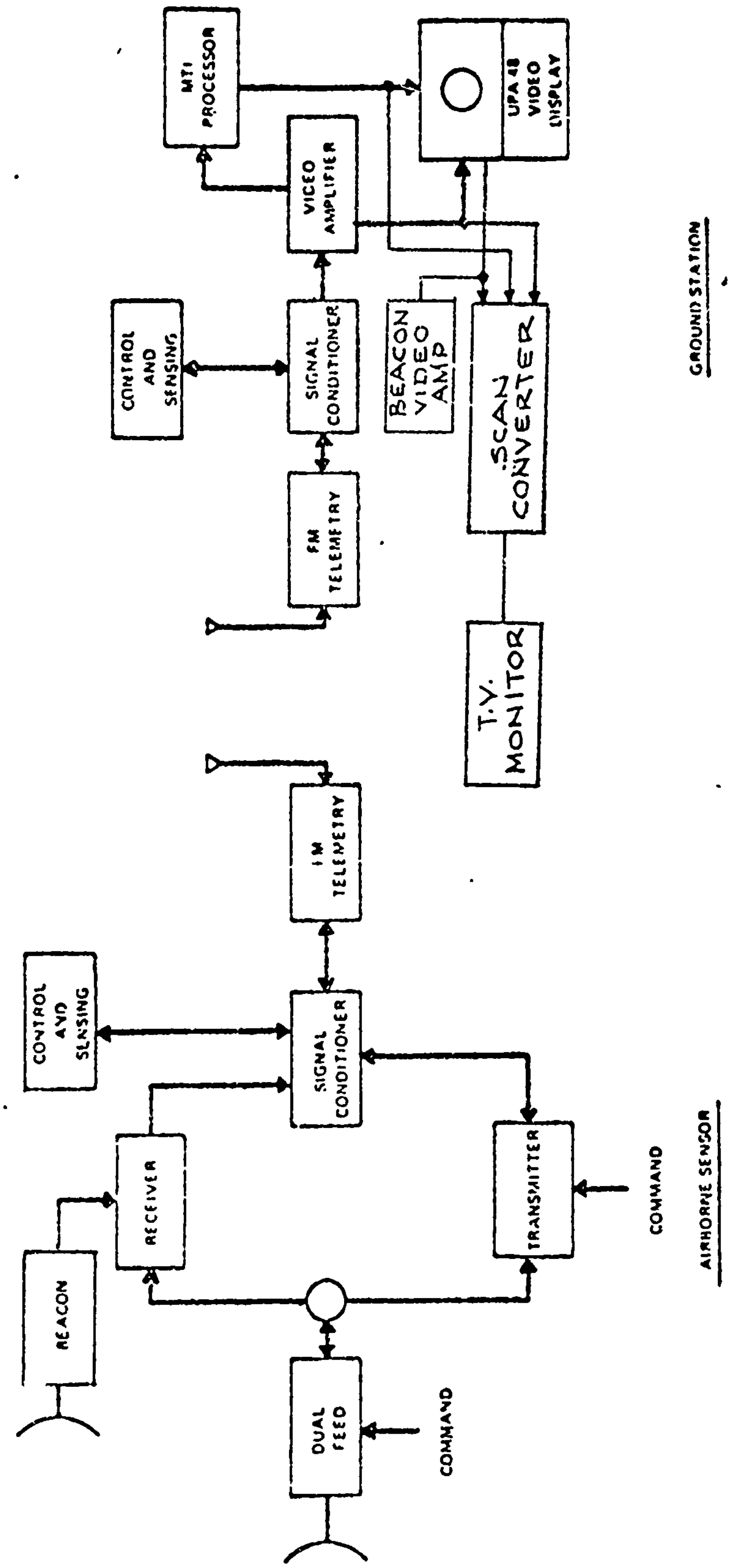
2.2.5 Target Interception

(C) Radar position data were used by the flight controller to navigate the helicopter to intercept stationary and moving targets. Targets were verified on the TV monitor. These tests were conducted at ranges varying from sixteen toforty miles.

3.0 SYSTEM DESCRIPTION

(C) The Egyptian Goose Radar System consists of a scanning K_a-band, non-coherent MTI radar (AN/APD-8), a telemetry control system and a ground control station. The radar and parts of the telemetry control system are carried aloft by a high altitude balloon or installed on a mountain top. The ground control station provides all signals to remotely operate the radar and it receives, processes and displays target information observed by the radar. The radar can detect a 2 1/2 ton truck, moving at a radial velocity greater than 2.0 miles per hour, at a range of 100 miles. Multiple targets can be tracked and their position can be displayed on the console in the ground control station. Equipped with an appropriate beacon, the NITE GAZELLE helicopter can be tracked by the radar and the helicopter position can also be displayed on a console. The helicopter flight controller can use the display information to navigate the helicopter to intercept the targets.

(C) A block diagram of the system is shown in Figure 2 and a complete description of the system is presented in Appendix A.



(U) SYSTEM DIAGRAM

FIGURE 2

4.0 BASIC FLIGHT PLAN

4.1 Test Objectives

(C) The main objectives of this test program were:

1) To evaluate the capability of the Egyptian Goose system to operate as a remotely controlled station.

2) To evaluate the capability of the system to detect and track moving targets.

3) To evaluate the systems ability to accurately determine the location of targets.

4) To evaluate the systems ability to provide navigational information for a remotely controlled aircraft.

4.2 Test Plans

(C) Egyptian Goose tests were conducted with the radar system located on Angel Peak, a distance of 16 miles from and approximately 6000 feet above the helicopter launch area. The NITE GAZELLE helicopter was tracked in the pad area and on flights to a distance of 40 miles from the radar site. Aircraft targets of opportunity were tracked when they were in radar range. Venicular targets were tracked in the launch area and in designated target areas. Corner reflectors were located in the target areas for reference. Radar range and azimuth measurements of various targets were compared with survey data.

(U) Test plans and results of individual tests are presented in Appendix C.

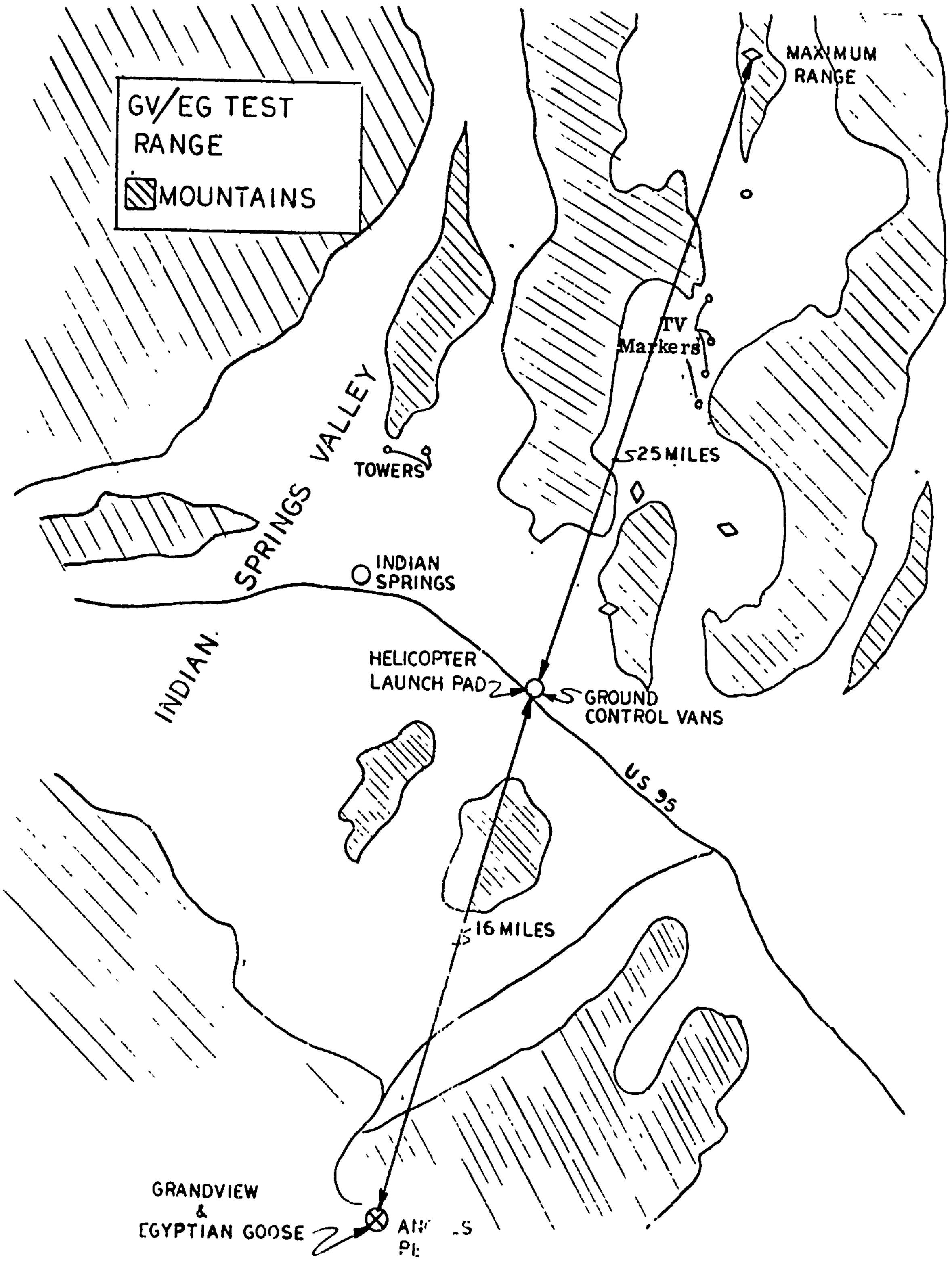

GV/EG TEST RANGE
MOUNTAINS
MAXIMUM RANGE
TV Markers
25 MILES
TOWERS
INDIAN SPRINGS VALLEY
INDIAN SPRINGS
HELICOPTER LAUNCH PAD
GROUND CONTROL VANS
US 95
16 MILES
GRANDVIEW & EGYPTIAN GOOSE

Figure 3

5.0 CONCLUSIONS AND RECOMMENDATIONS

(U) This section discusses conclusions and recommendations in the areas of:

Unmanned Radar Operation
Radar System Performance
Ground Station Performance

5.1 Unmanned Radar Operation

5.1.1 Conclusions

(C) The radar site was manned during the Nellis test program. However, this operation demonstrated that the system can function as a remotely operated station. Some initial antenna alignment was required to compensate for the greater than planned operational distance. This testing verified results obtained from previous unmanned balloon tests conducted in Florida.

5.1.2 Recommendations

(C) The airborne portion of the system should be used where continuous standoff surveillance is required. Tethered balloons should be used when terrain features do not provide sufficient altitude for the required target observation range.

5.2 Radar System Performance

5.2.1 Conclusions

(C) The radar system performance met design specifications. Surveillance of distant target areas was performed. Moving vehicular and aircraft targets were detected and tracked.

5.2.2 Recommendations

(C) Continue development improvements to increase range and azimuth resolution.

5.3 Ground Station Performance

5.3.1 Conclusions

(C) The ground station successfully provided all controls for the radar operation and effectively presented target information. The displayed information was used by the flight controller to navigate the NITE GAZELLE helicopter to intercept moving targets. Only one helicopter was under radar control during the test program.

5.3.2 Recommendations

(C) Verify the ability of the display system to provide monitoring capability for more than one helicopter.

(C) Conduct elevated radar tests to validate maximum range detection and location performance.

(C) Conduct additional tests to establish the accuracy of the ground truth tracking of helicopter reference to geographical coordinates.

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GLOSSARY

AGC	Automatic Gain Control
AM	Amplitude Modulation
CBU	Cluster Bomb Unit
CRT	Cathode Ray Tube
DAME	Distance and Azimuth Measuring Equipment
EG	Egyptian Goose
IF	Intermediate Frequency
MTI	Moving Target Indicator
PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency
TLM	Telemetry
VFO	Variable Frequency Oscillator

APPENDIX A

DESCRIPTION OF SYSTEM UNDER TEST

1.0 INTRODUCTION

(U) The system under test consisted of a modified scanning Ka-band, non coherent, MTI radar with a PPI scope and a television monitor. The television monitor is driven from a storage tube type scan converter. The radar equipment is contained in an assembly suitable for airborne use and is connected to the ground control station by a telemetry system. Operation of the system is performed from a console in the ground control station and command signals are telemetered to the radar equipment. The NITE GAZELLE helicopter was used as a target vehicle and the flight controller utilized Egyptian Goose position information for navigation.

(U) The following ground and airborne equipment comprise the system under test:

NITE GAZELLE Remotely Piloted Helicopter
NITE GAZELLE Ground Control Station
Egyptian Goose Ground Control Station
Egyptian Goose Radar System
Telemetry Control System

2.0 DESCRIPTION OF SYSTEM

2.1 NITE GAZELLE Remotely Piloted Helicopter

(C) The NITE GAZELLE Remotely Piloted Helicopter is a modified counter-rotating double bladed helicopter, which was originally developed by the U.S. Navy as an Anti-Submarine Drone Helicopter. The 20 foot diameter rotors are powered by a 330 horsepower gas turbine engine, yielding a 60 knot cruise speed with a payload of 1,200 pounds in fuel, weapons and sensors. Tactical radius of the NITE GAZELLE weapon or sensor system used with the Egyptian Goose Radar System depends on the type of equipment installed on the helicopter. A radar beacon on the helicopter is required to provide helicopter position information at the maximum radar range.

2.2 NITE GAZELLE Ground Control Station

(U) The command control station used in the test program is a portable, trailer type van that contains a pilot's position for remote control of the helicopter, and a fire control position for target acquisition and optical fire control capability.

(U) Three radio links connect the helicopter with the ground control station. Command and control orders are sent to the helicopter via a UHF link. Telemetered helicopter response data are sent to the ground via an S-band link and TV imagery is transmitted to the ground via an L-band link.

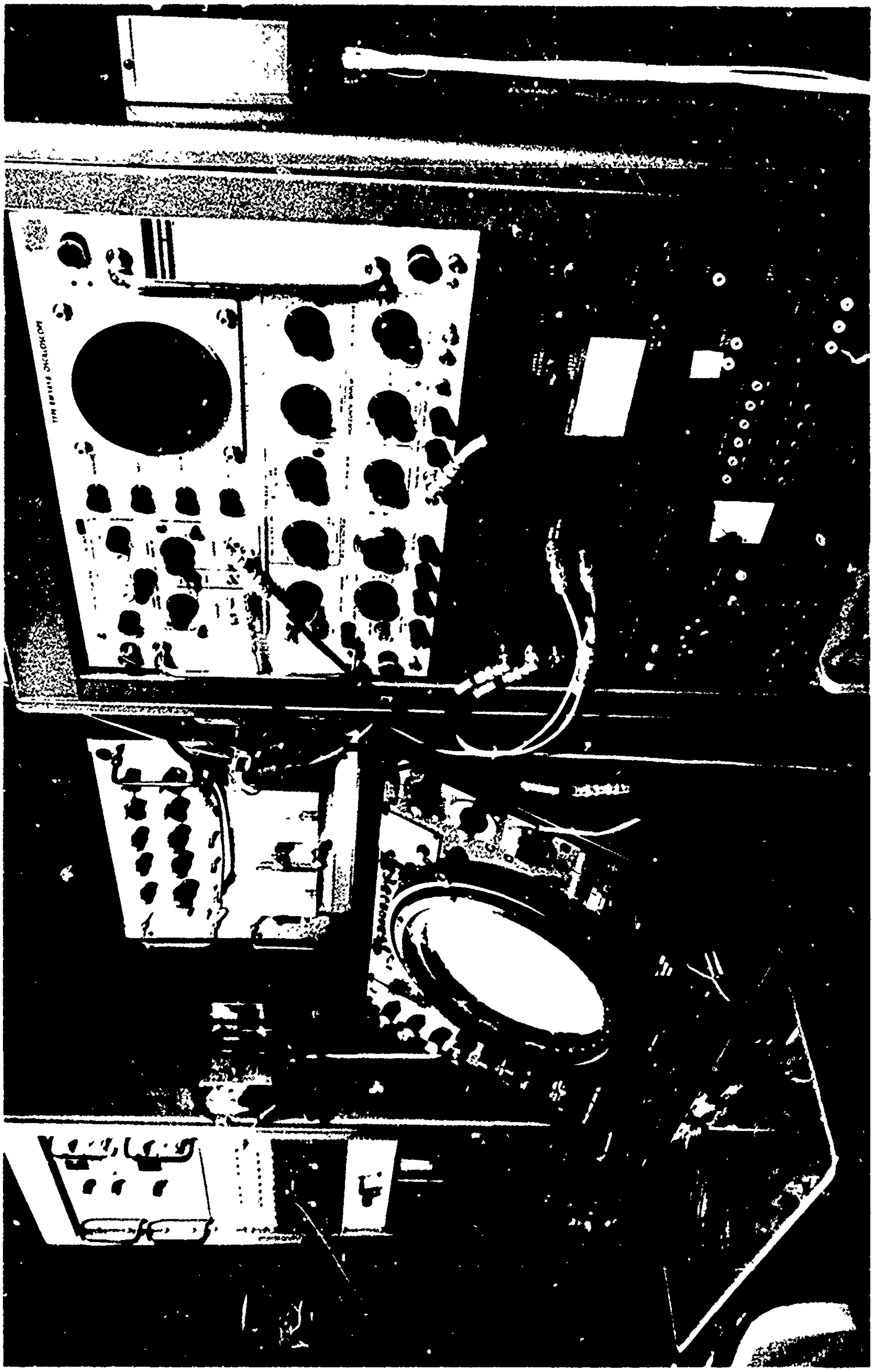
(C) The remote controller has a clear view of the helicopter, as it sits on the pad. through a window in the front of the van. He starts the engine and visually performs remote control lift-off. He operates the helicopter tactically to any point within electronic line of sight using Distance and Azimuth Measuring Equipment (DAME). Project Grand View, an airborne radio communication relay system, permits operations beyond ground line of sight. DAME data are used to chart the helicopter's position on a plotting board at the side of the controller's position.

(U) The weapon/sensor controller monitors the surveillance tracking and controls the mount while viewing TV video. He controls the TV camera zoom lens, the 16 mm film camera, and transmits the signals to activate the weapons or sensors.

2.3 Egyptian Goose Ground Control Station

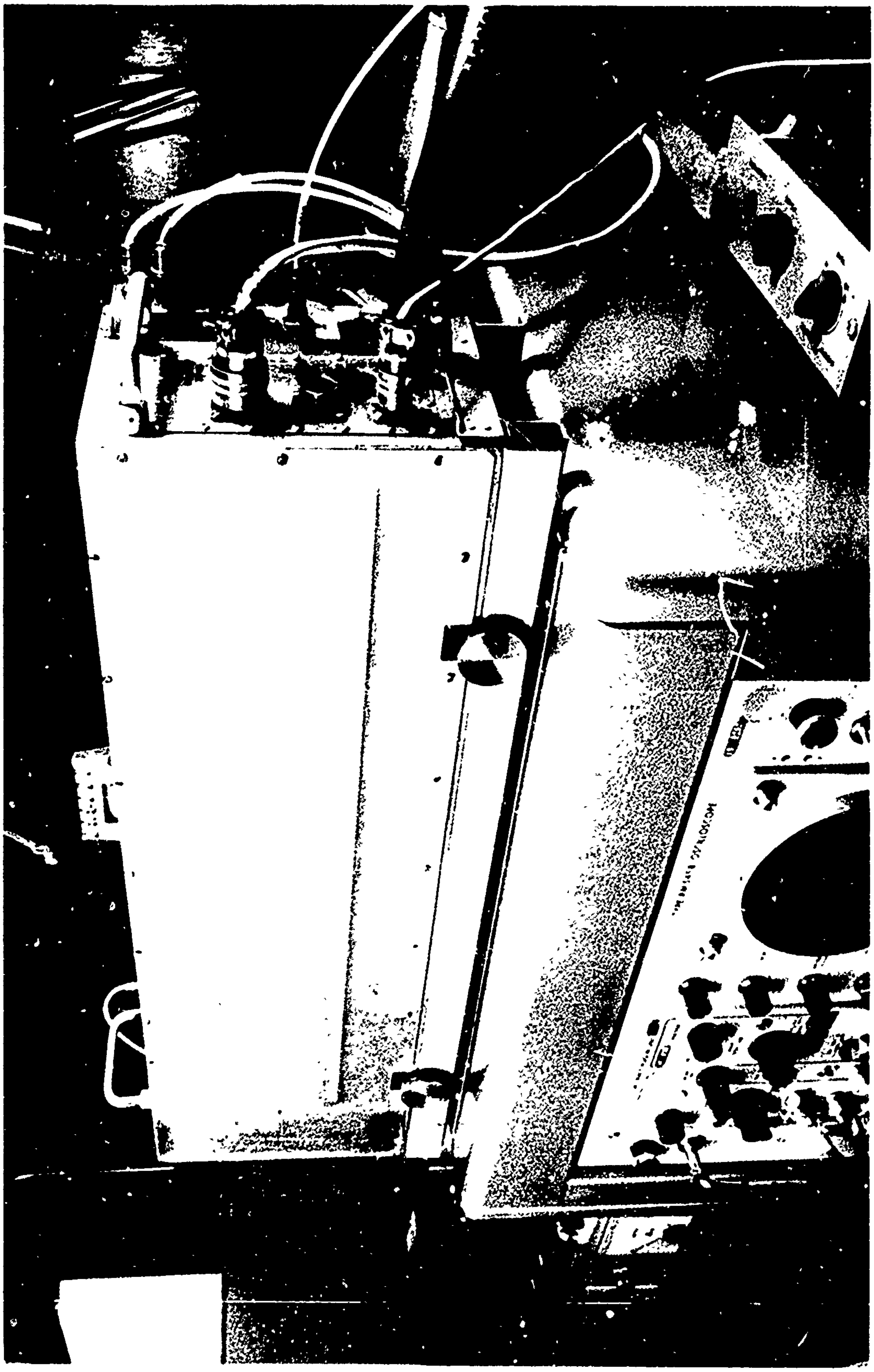
(C) The principal ground equipment for the Egyptian Goose Advanced Sensor System is housed in a modified 30 foot trailer that serves as a control center for personnel operating the airborne sensor system. Power is supplied by 60 Hz and 400 Hz motor generators. The van is divided into two main areas, one is used for operational control of the airborne sensor and the other for work and maintenan of equipment. The Sensor Operations and Control Area, Figure A1, contains from left to right, a floor mounted equipment rack that holds the telemetry transmitter, receiver and other equipment, an operator's console which displays either the radar imagery or MTI video and a second rack that contains the system control panel. These racks also contain various other items of equipment such as an oscilloscope, power supplies, a signal generator, antenna scan converters that drive the display sweeps and a control panel that may be used for both the video tape and oscillograph recorders. All flight information is recorded and can be played back and displayed on the consoles for post-flight analysis. In addition, the unit that processes the radar video for segregation of the moving target information is located on top of the right equipment rack. Figure A2, the second area within the ground control center, contains an Ampex FR900 tape recorder, an 8-channel Sanborn oscillograph recorder, a ceiling high panel that supports miscellaneous circuit breaker equipment and meters that display pertinent information concerning the 60- and 400- Hz primary power and tether cable status when the airborne system is located in a balloon. This area also contains four work benches, (Figure A3), heating and air conditioning equipment and space for locating two filing cabinets.

(U) A thirty-six inch parabolic antenna is used to transmit and receive telemetry signals. The antenna is controlled in azimuth and elevation by the operator in the van.



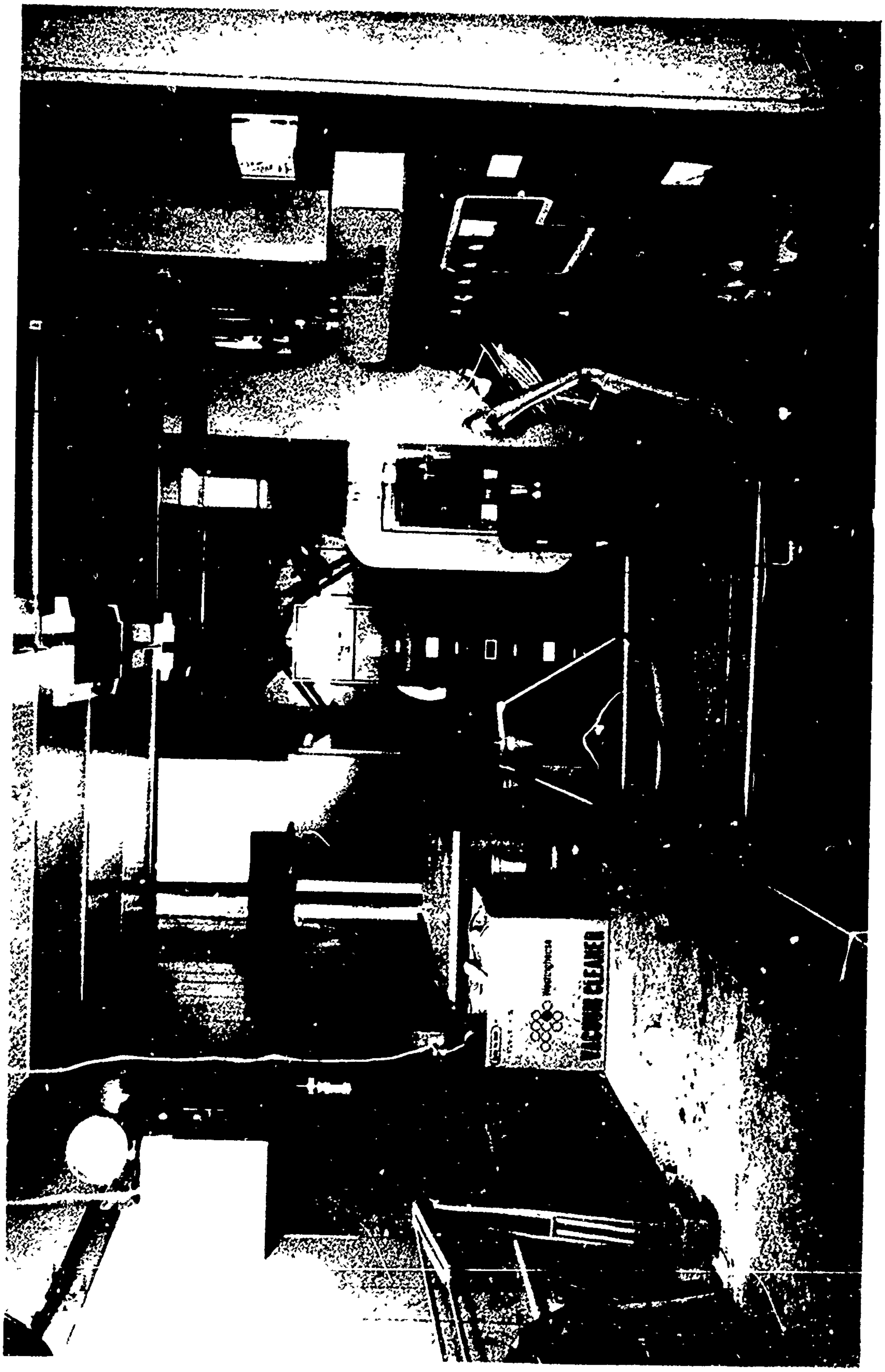
Sensor Operations and Control Area

Figure A1



Relay Video Processor

Figure A2



Work Bench Area

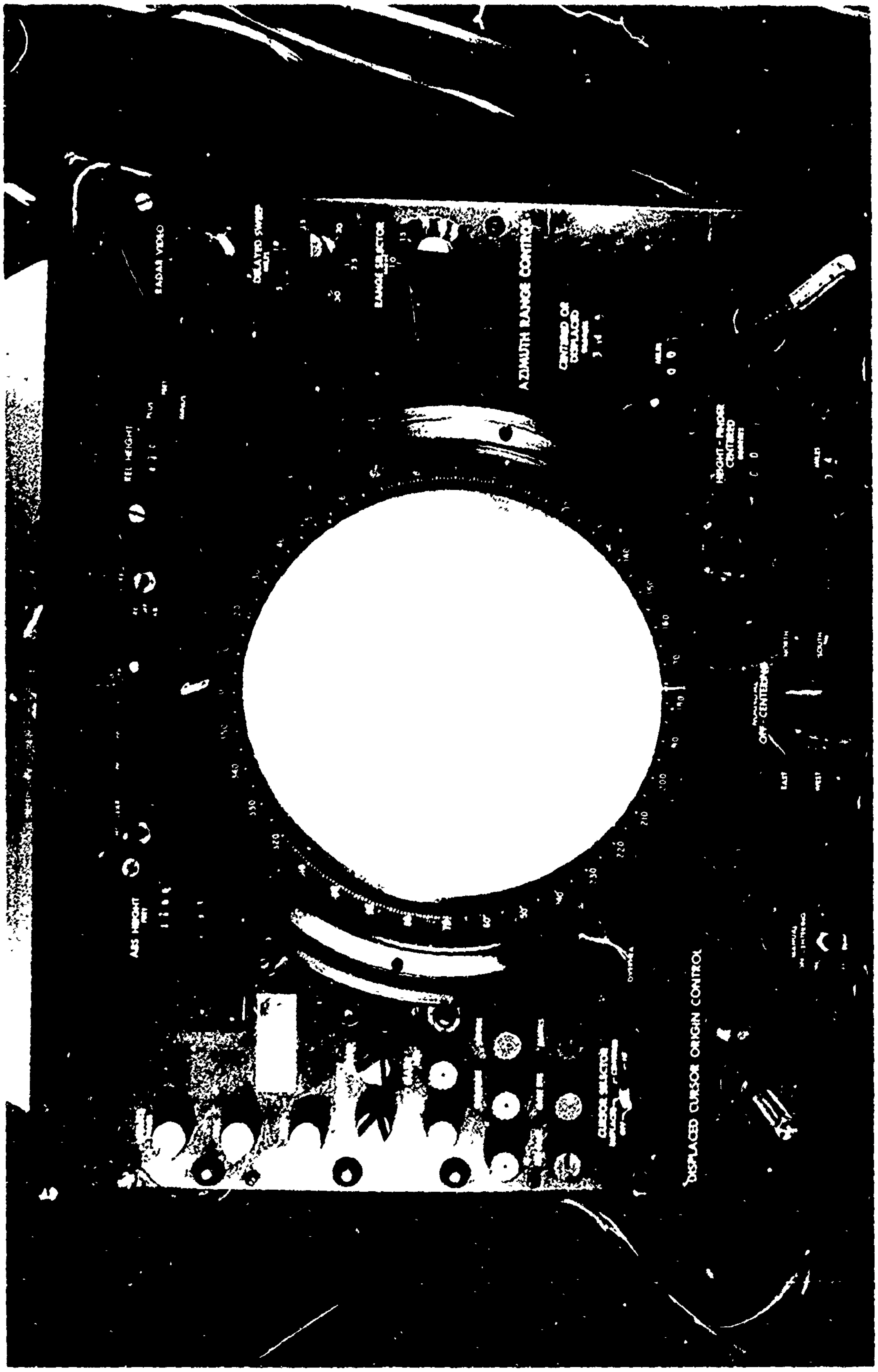
Figure A3

(U) The operator's display console, Figure A4, is a modified UPA-48 transistorized indicator that contains a 12 inch, high persistence cathode ray tube on which the radar video imagery and MTI is displayed. There are six principal controls that can be used with the display console, three of which are located on its upper right hand side. When the system is operated with the radar video control in position, both imaging and MTI information will be shown simultaneously on the CRT.

(C) Just below the Radar Video control is the Delayed Sweep which allows the operator to eliminate all information from the display below the range values indicated. If for example, the Delayed Sweep is at position 25, then no radar video information less than 25 miles in range will be displayed. The next control, designated as Range Selector, is used to establish the range that is represented by the distance from the center to the periphery of the CRT of the displayed video. For highest resolution, the Range Selector should be set at position 5 which would result in the diameter of the CRT representing a range of 10 miles. With the above setting of the delayed sweep at 25, information between the range of 25 and 35 miles would be presented. At the bottom of the CRT, a manual off-centering adjustment will move the center of the sweep from the center of the CRT outward and out of view such that any segment from 0 to 31 miles can be examined by the operator.

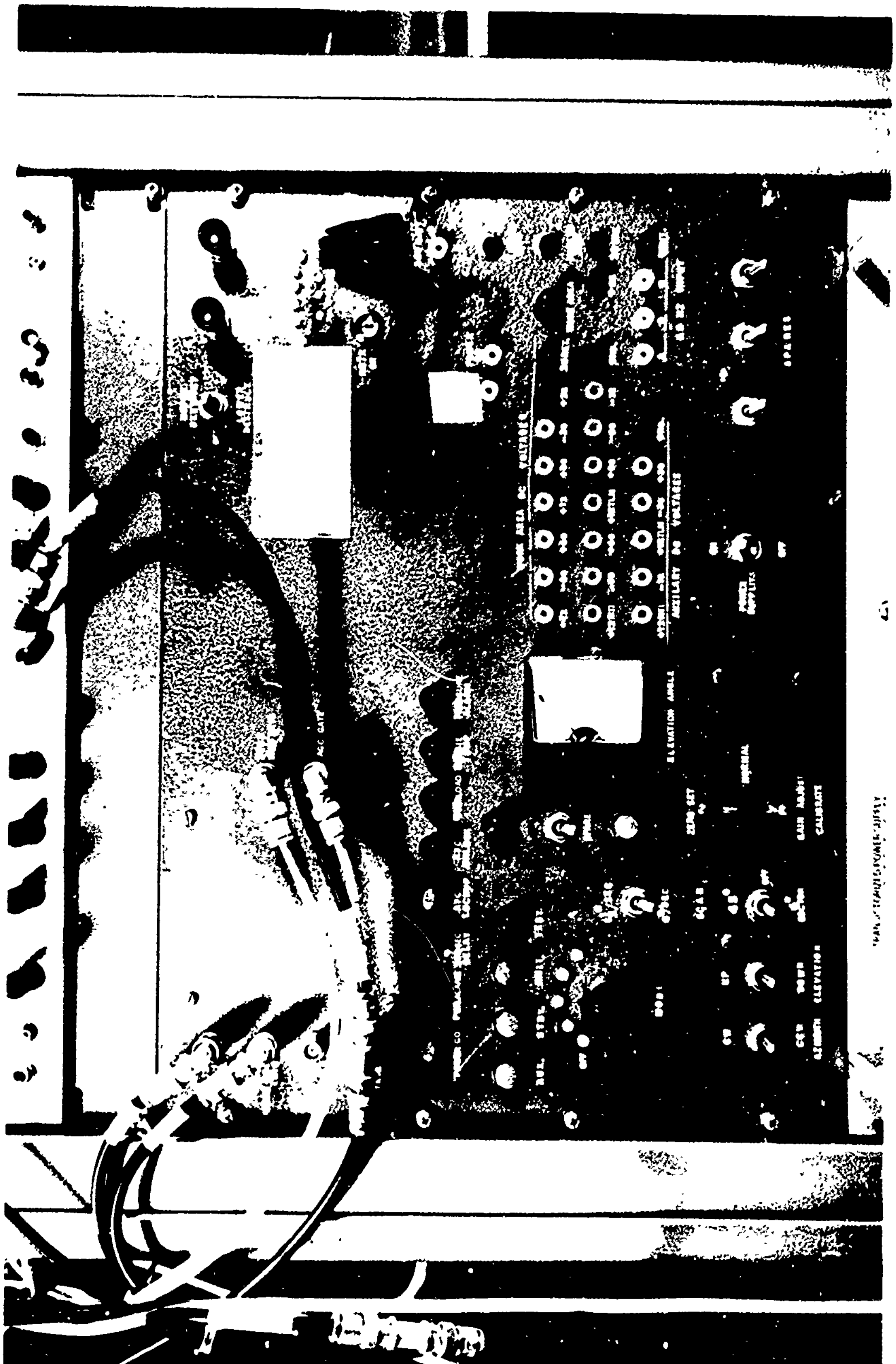
(C) The Operator's Control Panel, Figure A5, is located on the equipment rack to the immediate right of the Display Console. The Control Panel contains switches and lights that permit operation of the Egyptian Goose Radar System as well as a number of test points and related controls for the equipment. The radar system is initially operated through the use of a five-position mode switch. The first or auxiliary mode position applies power to the Display Console and MTI Processor. The standby mode permits 400 Hz power to be used by the airborne sensor in ground testing. After a 200 second delay to permit warm up of the radar transmitter and the various gyros, the mode switch may be turned to Transmit. When this occurs, the PRF pulses are sent to the airborne sensor through the telemetry link. This activates the transmitter and places the system in operation. The fifth mode enables the operator to test the airborne sensor sensitivity by blocking the radar return signals from the antenna into the pre-amplifier and substituting in its place an attenuated and calibrated signal from the transmitter output.

(C) In addition to the mode switch, there are four 2-position toggle switches that are used to command the movement of the radar antenna in azimuth and elevation. A 3-position toggle switch with the markings "zero set", "normal", and "gain adjust-calibrate", is used to calibrate the telemetry channels by first shorting all input signals and then introducing a 2.5 volt simulated command into all VFO downlink channels. The upper right hand area of the Control Panel is used to operate a coded emergency balloon descent system. Initial activation is accomplished by turning the key-operated "Transmitter-On" switch. An operational sequence transmits a coded AM signal to a balloon mounted receiver that in turn activates the descent system.



Operator's Display Console

Figure A4



Operator's Control Panel

Figure A5

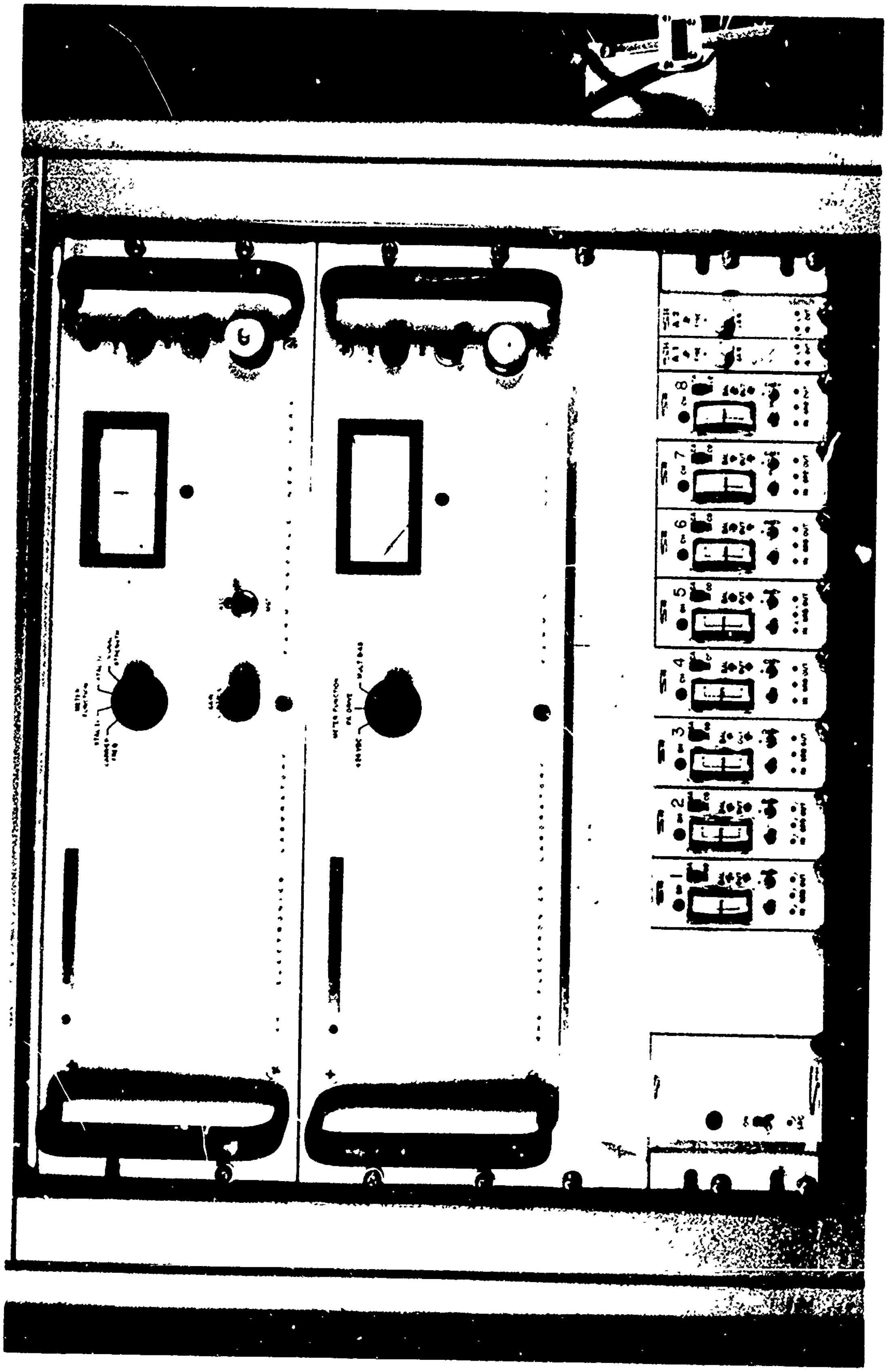
(C) In addition to the Control Panel, the equipment rack to the right of the Operator's Display Console contains an oscilloscope, 6 low-voltage power supplies and has the MTI processor mounted on top of it. The equipment rack to the left of the Operator's Display Console, however, contains a number of units needed for the operation of the sensor system. The top two panels, Figure A6, house the downlink telemetry transmitter and receiver. Immediately below these units is one containing 8 downlink frequency discriminators whose outputs are registered on zero center reading meters. The various amplifiers and circuits that process these and other telemetry signals are located below the discriminators. Figure A7, the panel rack immediately under the antenna controls, is used to convert the airborne sensor's scan signals from the azimuth servo into a form suitable to drive the scanning beam on the operator's display console. In addition to displaying the antenna sector scan and antenna sector scan center position signals, both of which are referenced to a directional gyro, the angular azimuth displacement of the antenna platform with respect to the balloon is also displayed. The unit below the azimuth scan converter, Figure A8, is an Instrumentation Control Panel used to control the video tape and oscillograph recorders as well as condition the radar imagery and MTI signals prior to their distribution to the display console, tape recorder or oscilloscope. The Instrumentation Control Panel permits display of the radar MAP video at the same time that the telemetry downlink signal is being recorded on the video tape. By use of this panel and the video tape, the entire mission or parts thereof can be played back for evaluation and MTI detection study. The remaining two units in this equipment rack are a signal generator that is used for test purposes and a power supply.

(C) The Egyptian Goose Scan Converter Display System provides the observer and helicopter pilot with a high resolution TV monitor to show helicopter position and potential targets. The 40 line PPI scope pictures are converted for display on a 945 line TV monitor. The targets or helicopter appear as white dots on a dark background. The storage capacity of the system allows the total path of the target or helicopter to be displayed as a line. The system could also display a ground truth map of the general area on the same screen with the target information.

2.4 NITE GAZELLE/Egyptian Goose Radar System

(U) The Egyptian Goose Radar System is composed of an elevated radar system and telemetry system to control the radar and return radar data to the ground station. Figure A9 shows the radar antenna.

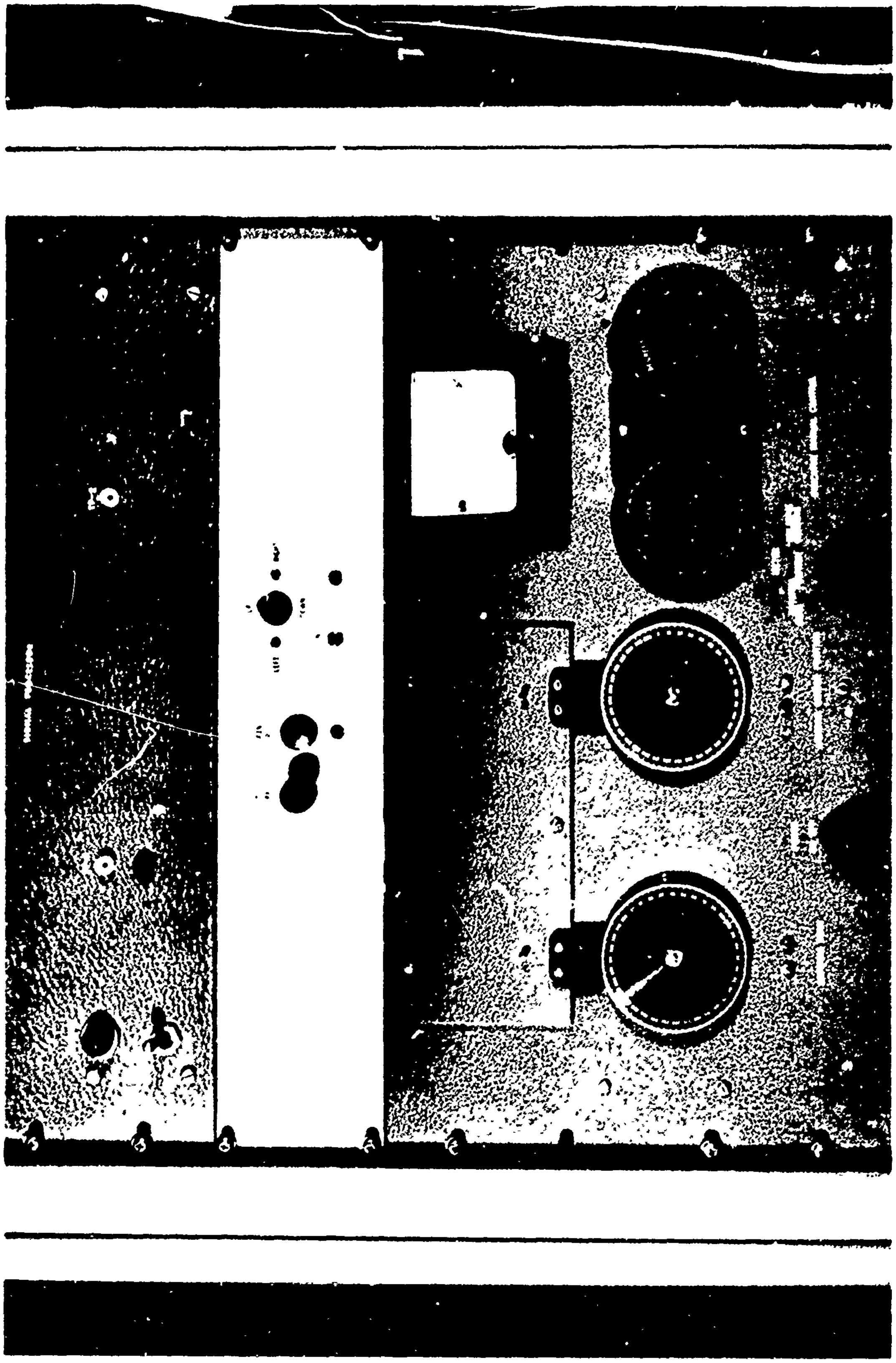
(C) The two watt output of the telemetry system maintains operation and control of the radar system. Seventeen uplink and sixteen downlink channels carry information between the radar and ground station. Segregation of this information for the two-way transmission is realized by having the uplink function at a center frequency of 1820 MHz and the downlink operation at a center frequency of 1455 MHz. As shown in Figure A10, the telemetry equipment of the radar, for an example, consists of a receiver tuned to an 1820 MHz



Downlink Telemetry Receiver and Transmitter Panels

Figure A6

UNCLASSIFIED

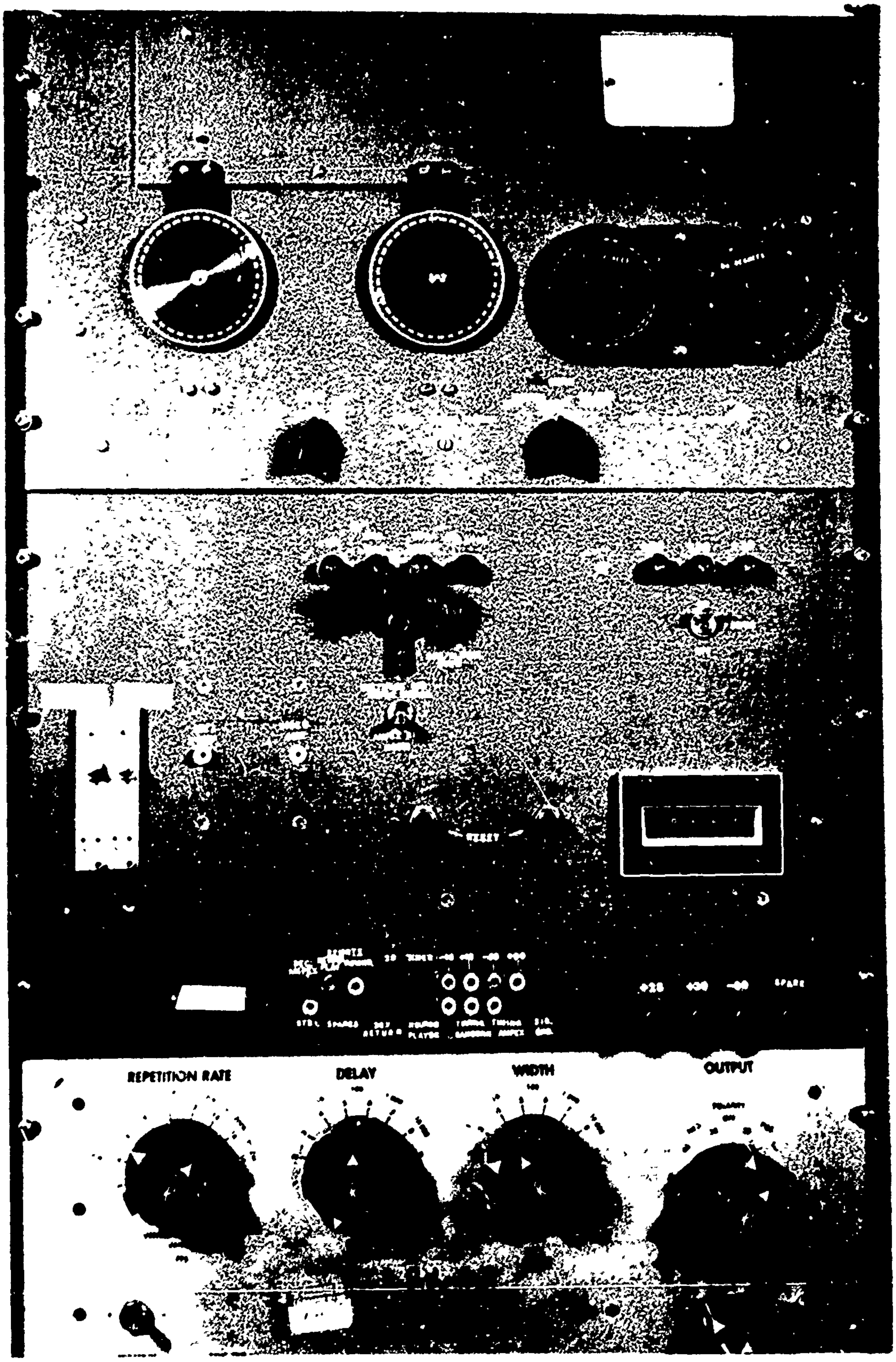


TLM Antenna Control-DC/Synchro Converter

Figure A7

UNCLASSIFIED

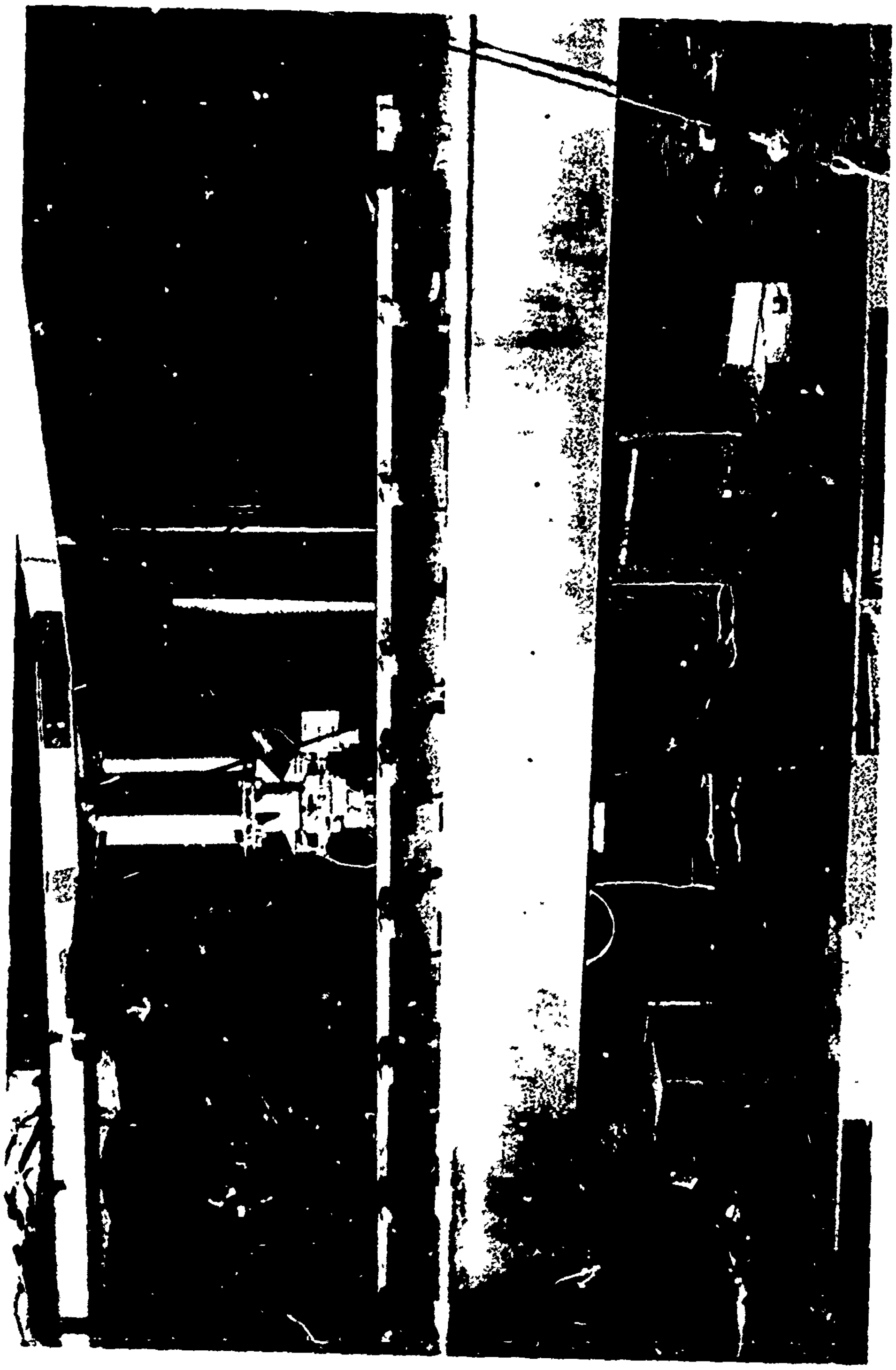
UNCLASSIFIED



Instrumentation Control Panel

Figure A8

UNCLASSIFIED



AN/APD-8 Radar Antenna

Figure A9

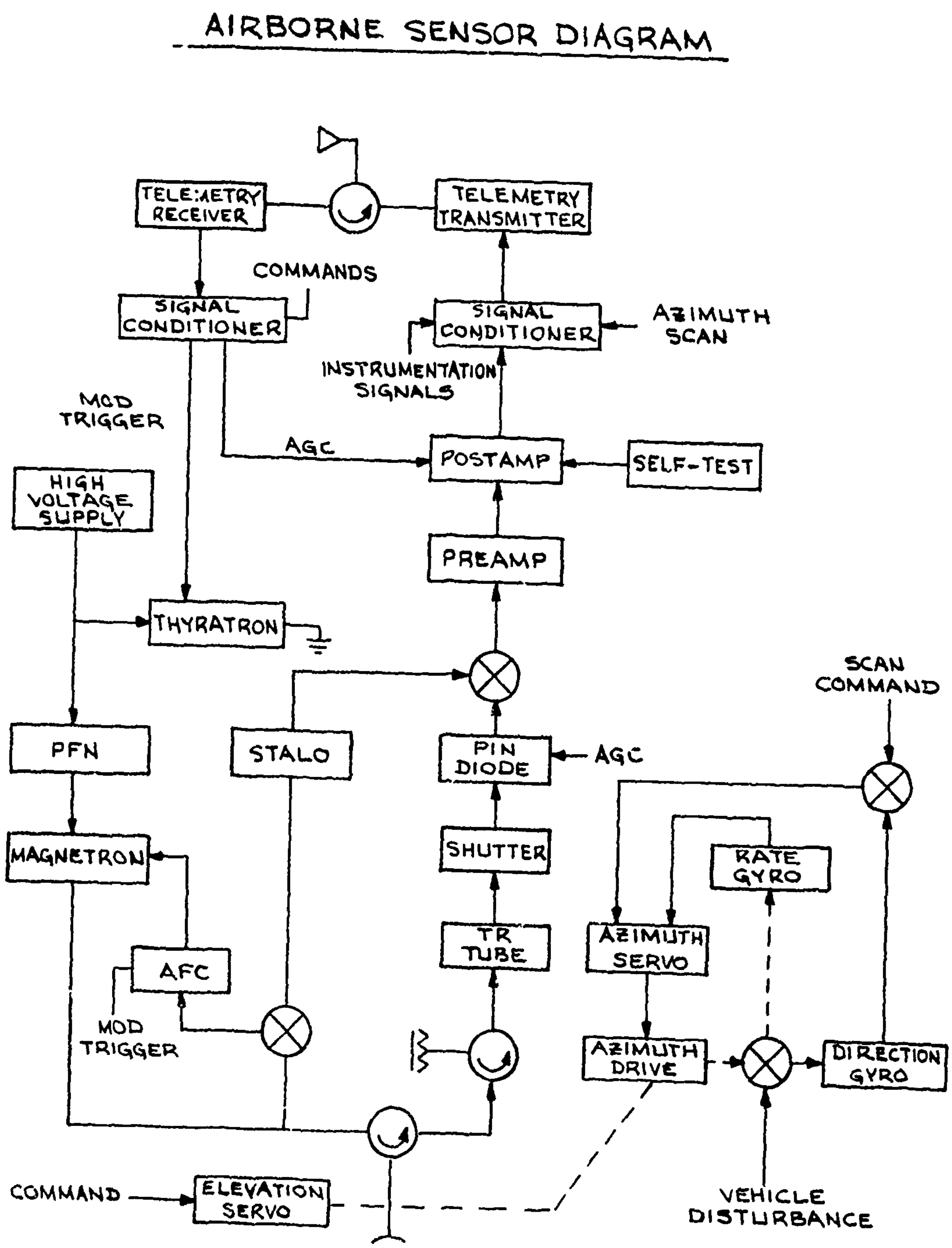

AIRBORNE SENSOR DIAGRAM
TELEMETRY RECEIVER
TELEMETRY TRANSMITTER
COMMANDS
SIGNAL CONDITIONER
SIGNAL CONDITIONER
AZIMUTH SCAN
INSTRUMENTATION SIGNALS
MOD TRIGGER
AGC
POSTAMP
SELF-TEST
HIGH VOLTAGE SUPPLY
PREAMP
THYRATRON
SCAN COMMAND
PFN
STALO
PIN DIODE
AGC
MAGNETRON
SHUTTER
RATE GYRO
AZIMUTH SERVO
TR TUBE
AFC
MOD TRIGGER
AZIMUTH DRIVE
DIRECTION GYRO
COMMAND
ELEVATION SERVO
VEHICLE DISTURBANCE

Figure A10

transmitter and a 1455 MHz receiver. In addition, signal conditioning equipment at both the airborne and ground locations are used to compile and segregate the 17 and 16 separate channels of information through the use of both fixed and variable frequency oscillators in conjunction with fixed and variable frequency detectors.

(C) Information contained in the uplink channels consists of commands to the servo controls as well as the radar PRF and AGC pulses that are used to actuate the transmitter and control the gain of the receiver, respectively. Downlink channels contain the radar video from the receiver and servo scan information that generates the display sweep as well as a number of instrumentation signals. Referring to Figure A10, the returning radar signals are generated in the receiver assembly by mixing the returned K_a-band imaging information with the output of a K_a-band scan such that a 60 MHz center-frequency IF is created.

(C) The radar transmitter uses a tunable magetron to generate 110 kw of peak power at a PRF of 930 Hz with a pulsewidth of .2 or .6 microseconds. The cosecant squared antenna transforms the transmitter output into a 0.13 degree azimuth beam that produces constant energy at the ground level over an elevation profile from -3.2 to -30 degrees. Ground imaging returns are received through the same antenna, converted to a video signal, transmitted to the ground station, shown to and displayed on the operator's console. The display console can simultaneously or selectively present the MTI or normal video signals. In the MTI mode of operation, stationary ground targets are attenuated by 36dB and as a result moving targets are clearly visible. The radar design parameters are summarized in Table A1.

TABLE A1 (Title Unclassified/Table Confidential)

EGYPTIAN GOOSE II
RADAR DESIGN PARAMETERS

Range	10 - 100 statue miles
Resolution	
Range	100 feet at .2 microsecond 300 feet at .6 microsecond
Azimuth	500 feet at 50 miles
Operational Altitude	up to 25,000 feet
Airborne System	
Weight (not including power cable)	650 lbs.
Power Consumption	2.0 kw, 400 Hz 3 ϕ

Table A1 Continued

MTI	
Swath	20 statute miles
Range gates	300
Range gate width	0.65 microsecond
Minimum detectable velocity	2.0 miles per hour
Blind speeds	7.8, 15.6, 23.4, etc., knots
Antenna	
Total rotation available	continuous
Scan limits (ground selectable)	± 10 degrees, ± 45 degrees
Scan rates (ground selectable)	2 degrees/sec., and 4 degrees/sec.
Beamwidth (azimuth)	0.13 degree
Antenna length	13 feet
Elevation pattern	$\csc^2 \theta \quad \cos^{1/2} \theta$
Depression angle	-3.2° to -30°
Elevation tilt coverage adjustment	0° to -7°
Antenna gain	45.5 dB
Polarization	
Receive	Horizontal/vertical
Transmit	Horizontal
Transmitter & Receiver	
Frequency (K_a-band)	34.85 GHz (nominal)
Pulsewidth	.2 or .6 microseconds
Peak power output (magnetron)	110 kw
PRF	930 pps
Noise figure (parametric amplifier)	7 dB

PPI Display

The indicator receives target video, scanning and trigger information and produces a PPI display of MAP and/or MTI video with off-centering and delayed sweep control. Range is also variable.

Total range coverage available	100 statute miles
Azimuth coverage	360°, or any sector, determined by synchro-converter inputs
Off-centering	Variable up to 60 miles in any direction

Table A1 Continued

Sweep start delay	Variable from 5 to 80 miles

"A" Scope Display

A dual channel Tektronix oscilloscope is included in the control console to present MAP and MTI simultaneously (amplitude versus time).

Telemetry Uplink System	
Frequency	1.820 GHz, 10 MHz bandwidth
Transmitter power	2 watts
Command channels	10 each 75 Hz wide (800 - 1625 Hz)
Discrete signals	Radar trigger, AGC gate
Noise figure	6 dB
Antenna gain	20 dB at 1.82 GHz; 18 dB at 1.455 GHz
Beamwidth	6° at 1.82 GHz, 7° at 1.455 GHz
Telemetry Downlink System	
Frequency	1.455 GHz, 10 MHz bandwidth
Transmitter power	2 watts
Alarm circuits	4 in a 5200 Hz to 6200 Hz bandwidth
Variable channels	8, each + 7.5% peak deviation in a 400 Hz to 4000 Hz bandwidth
Noise figure	6 dB
Antenna gain	7 dB
Beamwidth	70 degrees

Descent System

Descent capability is mechanized through an encoder transmitter in the van and an onboard receiver.

Telemetry Ground Station	
Power output	2 watts
Antenna gain	8 dB
Frequency	430 MHz
Coding channels	IRIG 2, 4, 6
Scan Converter and TV Display	
Range Coverage	
#1	11.5 - 21.5 nautical miles
#2	11.5 - 31.5 nautical miles
#3	21.5 - 31.5 nautical miles
#4	21.5 - 41.5 nautical miles
#5	0 - 80 nautical miles
Azimuth coverage	360°, or any section of a circle as determined by the radar

APPENDIX B

SCHEDULED OPERATIONS

(U) Table B-1 presents a list of the tests scheduled at Nellis AFB. It also includes a summary statement of test results.

TABLE B-1 (Title Unclassified
Table Confidential)

SUMMARY OF SCHEDULED OPERATIONS FOR EGYPTIAN GOOSE

Date	Test No.	Plan	Comments
9/1 and 9/2/70	Equip. Evaluation	Detect Targets	Truck targets were detected.
9/29/70	Equip. Evaluation	Determine Range and Azimuth Resolution	Test show design specifications of 150 feet range and 160 feet azimuth were met.
10/6/70	Check Flight	Skin track Nite Gazelle	This first test was not successful. The helicopter was not detected.
10/8/70	Check Run	Track 3 1 1/2 ton trucks	Trucks were resolved and tracked in all directions. Trucks were visible in MTI and map modes.
10/13/70	Equip. Evaluation	Track truck targets	Vehicles were detected when radial velocity was greater than 2.5 mph.
10/14/70	Check Flight	Skin track Nite Gazelle	First run cancelled to repair aircraft command system. On the second run, Egyptian Goose position information was obtained and verified by DAME.
10/20/70	Operations Check	Track Targets of opportunity	Difficulties were encountered in tracking the Nite Gazelle. Acquisition information is required.
11/17/70	220	Hand over and vectoring practice	Three runs completed. The helicopter was vectored to intercept stationary and moving targets. Beacon checks were satisfactory.

Table B-1 Continued

Date	Test No.	Plan	Comments
12/8/70	231	Locate and track two trucks and 1 helicopter	Scan jitter prevented acquisition on trucks. Helicopter beacon was tracked. Compensation for timing delay fixed jitter problem.
12/9/70	231A	Intercept Trucks	Power surges at Angel Peak caused the test to be delayed. High winds moved the telemetry and command antennas and the test was cancelled.
1/14/71	221	Compare EG and surveyed position data	Six targets were located. Angular variations were from 0.5° to 3.5°. Range differences were from 60 to 785 yards.
1/15/71	222	Target location flight	Test was aborted in flight. Egyptian Goose transmitter failed and helicopter control became marginal.
1/18/71	222	Target location flight	Aborted because of power problem at Angel Peak and TV problem on helicopter.
1/18/71	222	Target location flight	Six runs were completed. Radar angle readings varied from 0.5° to 3.5° from survey data. Range differences varied from 50 yds. to 520 yds.
1/19/71	222	Target location flight	First run was aborted because of a TV problem. Second run because of a helicopter power problem.
2/9/71	Check Flight	Track Nite Gazelle	Cancelled because of Egyptian Goose component failures. Targets of opportunity were tracked after repairs were made.
2/11/71	Check Flight	Range and bearing calibration	Nine targets were plotted.
2/24/71	Check Flight	Track F-4 aircraft	Cancelled because of Egyptian Goose equipment failures.

Table B-1 Continued

Date	Test No.	Plan	Comments
2/25/71	Check Flt.	Track various targets	The helicopter and F-4's were successfully tracked.
9 13/71	Check Flt.	Evaluation	Cancelled prior to flight for various reasons.
9/22/71	343 & 347	Mid/max range flight	Two flights were aborted due to no beacon returns. Transponder was checked by Westinghouse, but no problem was detected.
9/26/71	343 & 347	TM/TV Equip. Check & G.V. max range	Cancelled prior to flight due to Relay Link Video not operationally ready.
10/18/71	345 & 346	Radar beacon eval. extended range & G.V. midrange check	Cancelled prior to flight due to heavy snow.
10/22/71	346 & 347	G.V. midrange & G.V. max-range	Marked two towers, then cancelled test since Egyptian Goose beacon was not working due to faulty connection on aircraft.
11/9/71	343	Midrange	One hour flight time was completed at midrange. TV and TLM were placed in relay mode at 6000 yards. In-flight beacon checks indicate the beacon antenna should be relocated.
11, 10, 71	Check Flt.	Test relocated antenna	Helicopter was flown at 500 and 1000 feet. The relocated beacon antenna provided adequate signal.
11 11, 71	343 & 347	Mid and max-range	Poor TV and TLM in the relay mode. Aircraft flown to within 2 miles of target in direct mode (approximately 23 mile range). EG provided position information.
11 12, 71	343 & 347	Mid and max-range	A short range flight was flown in the relay mode. Severe telemetry noise was observed. EG provided position information.

APPENDIX C

FLIGHT TEST DATA FOR EGYPTIAN GOOSE

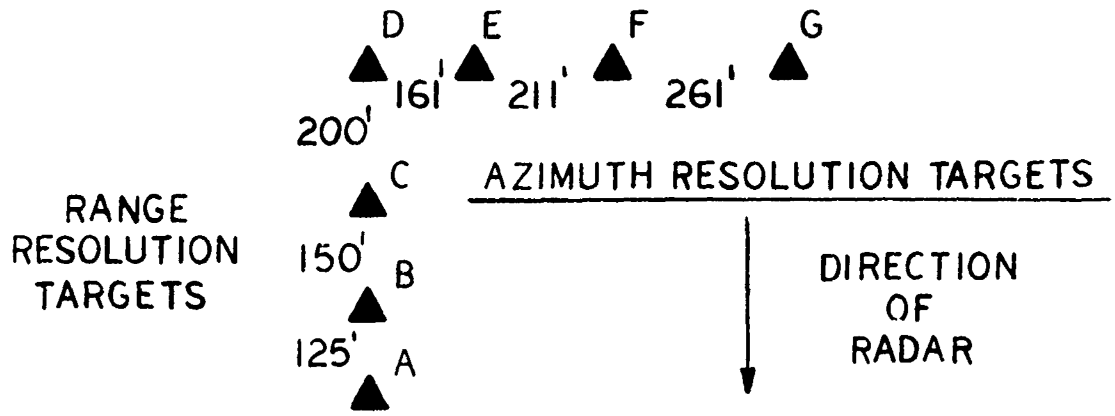
(U) This appendix presents the test objectives, flight parameters and results of tests completed at Nellis AFB.

INITIAL EQUIPMENT EVALUATION
Flight No. - Test No. -
1 & 2 September 1970

(C) This test was conducted to determine the ability of the radar system to detect vehicular traffic moving around fixed target arrays in a desert environment. A 2 1/2 ton truck made three test runs at speeds and directions that presented various radial velocities to the radar. The fixed targets were easily detected when the radar was operated in the map mode. The moving vehicle was also detected because it changed position during the scan period. No positive detections were observed when the radar was in the MTI mode and the truck was traveling on the dry lake bed. This was expected since the radar requires background clutter to operate in the MTI mode. When the truck was moving through the sparsely cluttered terrain off the dry lake bed it was detected when the radar was operating in the MTI mode. This test was conducted at a slant range that varied from 18 to 20 miles. Signal strength measurements made at these ranges indicate that the truck would have been detected at a range of 100 miles.

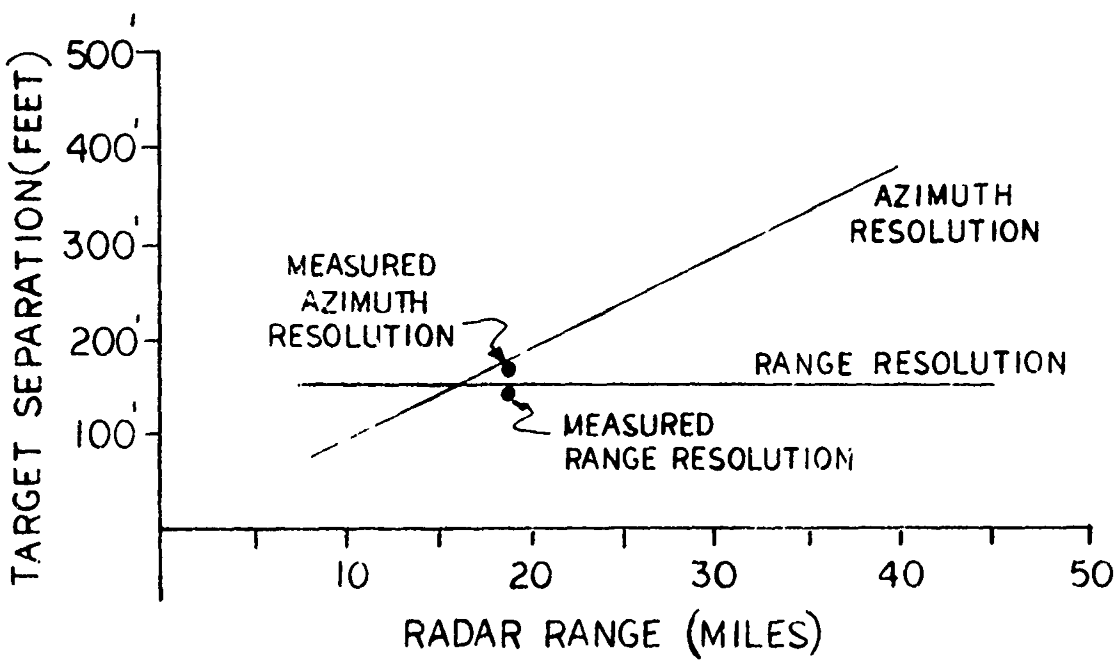
RESOLUTION TEST
Flight No. - Test No. -
29 September 1970

(C) This test was conducted to evaluate the resolution capability of the radar system. A test pattern, Figure C1, consisting of corner reflectors was placed in the general test area. The gain of the radar was then switched through four manual modes of operation and the Automatic Gain Control Mode. Observations were made and the results are tabulated in Table C1. Figure C2 shows the calculated design resolution. Test results indicate that the radar meets the design resolution requirement.



CORNER REFLECTOR ARRANGEMENT
FOR
RADAR RESOLUTION TESTS

FIGURE C1



RADAR RESOLUTION (DESIGN)

FIGURE C2

RADAR MODE	OBSERVATION	RANGE TARGETS A	B	C	D	AZIMUTH TARGETS D	E	F	G
TARGET SEPARATION (FEET)		125'	150'	200'		161'	211'	261'	
MAN 2	1	←→	←→	X	X	X	X	X	X
	2	←→	←→	X	X	X	X	X	X
	3	←→	←→	X	X	X	X	X	X
MAN 3	1	←→	←→	X	X	X	X	X	X
	2	←→	←→	X	X	←→	←→	X	X
	3	←→	←→	X	X	X	X	X	X
MAN 4	1	←→	←→	←→	X	←→	←→	X	X
	2	←→	←→	←→	X	←→	←→	X	X
	3	←→	←→	←→	X	←→	←→	X	X
MAN 7	1	←→	←→	←→	X	←→	←→	X	X
	2	←→	←→	←→	X	←→	←→	X	X
	3	←→	←→	←→	X	←→	←→	X	X
AGC	1	←→	←→	←→	X	←→	←→	X	X
	2	←→	←→	←→	X	←→	←→	X	X
	3	←→	←→	←→	X	←→	←→	X	X

X RESOLVABLE TARGETS

←→ NO TARGET SEPARATION

TABLE C1

RADAR RESOLUTION OBSERVATIONS

EQUIPMENT OPERATIONAL CHECK
Flight No. 1 Test No. -
6 October 1970

(C) This test was conducted to evaluate the ability of the Egyptian Goose Radar System to locate and track a NITE GAZELLE helicopter. Two attempts were made to skin track the QH-50D helicopter while it was on a check flight at a range of approximately 20 miles from the radar. These attempts were unsuccessful. The inability of the system to track the aircraft is believed to be due to procedural inexperience rather than hardware limitations.

EQUIPMENT OPERATIONAL CHECK
Flight No. - Test No. -
8 October 1970

(C) This test was conducted to evaluate the ability of the Egyptian Goose to locate and track three truck targets moving at various speeds and headings. Pictures were taken in addition to the visual display on the UPA-48 monitor, and target resolution on film was superior to the radar display. Targets in cluttered areas on radial paths were clearly visible in the MTI mode when they were approaching and receding from the Angel Peak site. On the clutter free area of the dry lake bed the targets were visible when the radar was operated in the map mode.

EQUIPMENT EVALUATION
Flight No. - Test No. -
13 October 1970

(C) This test was conducted to determine the ability of the radar equipment located on Angel Peak to detect and track three vehicles in the dry lake bed area at distances of 16 to 25 miles. The 1 1/2 ton trucks were consistently and positively detected when speeds were greater than a radial velocity of 2.5 mph. This performance was consistent with design specifications. The system also provided directional information to vector traffic to predetermined areas.

EQUIPMENT OPERATIONAL CHECK
Flight No. 2 Test No. -
14 October 1970

(C) This test was conducted to evaluate the ability of the Egyptian Goose to locate and track a NITE GAZELLE helicopter. Flight altitudes were 500 and 1.000 feet and airspeed varied from 20 to 40 knots. The Egyptian Goose

system was able to detect the helicopter when position information was provided at the start of the data run. The system was then able to provide continuous position information to the control van for the balance of the flight. DAME confirmed position data provided by the Egyptian Goose Radar System. Flight duration was forty-three minutes. Since the helicopter has low radar reflectivity and is flying over terrain with little clutter, a beacon installed on the helicopter is required to assure acquisition.

TARGETS OF OPPORTUNITY
Flight No. - Test No. -
20 October 1970

(C) This test was conducted to evaluate the capability of the Egyptian Goose to track targets of opportunity. An attempt was made to track a helicopter launched from the pad area. Since helicopter take-off time, operation altitude, and location were not known, results were poor. This test demonstrated that flight tests specifically for Egyptian Goose must be scheduled in the future.

TARGET HAND OVER
Flight No. 3 Test No. 220
17 November 1970

(C) This test was conducted to evaluate the ability of the Egyptian Goose Radar System to locate stationary targets and provide navigation information to the NITE GAZELLE flight controller so that the helicopter could be vectored to intercept the targets. Helicopter flight altitude was 500 feet and airspeed was minimum safe. The test was conducted at a range of approximately 20 miles from the radar site. A secondary test objective was to evaluate the performance of the beacon installed on the helicopter. Beacon performance was checked on the first pass and operation on headings between 320° and 240° was satisfactory. Performance was marginal between headings of 320° to 340° and from 220° to 240°. The truck was located and the Egyptian Goose Radar System provided vectoring to the helicopter. The run was terminated early because of a conflict over range time. Flight duration was forty-three minutes.

TARGET HAND OVER
Flight No. 4 Test No. 220A
17 November 1970

(C) This test was conducted to evaluate the ability of the Egyptian Goose Radar System to locate a moving target and to provide navigation information to the flight controller in order to vector the NITE GAZELLE helicopter to

intercept the target. Flight altitude was 500 feet and airspeed was minimum safe. Radar range to the target was approximately 20 miles. On the first pass at the target the helicopter was moving too fast and another target was selected by the Egyptian Goose radar operator. Range and heading information provided to the flight controller enabled him to fly the helicopter to intercept the moving target. Mount camera film was exposed while the target was being tracked by the helicopter TV system. Flight duration was thirty minutes.

EQUIPMENT OPERATIONAL CHECK
Flight No. 5 Test No. 231
8 December 1970

(C) This test was conducted to evaluate the ability of the system to locate and track two moving truck targets, and vector the helicopter to intercept them. Flight altitude was 1,000 feet, helicopter velocity was minimum safe, and the trucks were 400 feet apart moving 10 mph at a radar range of approximately 20 miles. Helicopter approach was started four miles from the trucks on a heading of 270 degrees. The Egyptian Goose acquired the helicopter three minutes after the mission started. Immediately after acquiring, the system became inoperative and the run was aborted. On the second run the helicopter beacon was acquired but the test was cancelled because of jitter in the scanner. Compensation for the propagation delay between control site and Angel Peak corrected the problem. Flight duration was forty-five minutes.

TARGET LOCATION
Flight No. - Test No. 221
14 January 1971

(C) This test was conducted to evaluate DAME and Egyptian Goose position data. The Egyptian Goose beacon was placed in a truck and as it was driven to three targets, it was tracked by DAME and Egyptian Goose. At the three locations, distance and angle readings were recorded. These recordings are shown in Table C2.

TABLE C2 (Title Unclassified/Table Confidential)

DAME AND EGYPTIAN GOOSE TARGET LOCATIONS

Target	Reading	Survey		DAME		Egyptian Goose	
		range(yds)	Az(°)	range(yds)	Az(°)	range(yds)	Az(°)
1	1			7840	9°	7800	12.5°
2	2	8200	51.5			7400	45°
2	3	8200	51.5			8400	47°

Table C2 Continued

Target	Reading	Survey range(yds)	Survey Az(°)	DAME range(yds)	DAME Az(°)	Egyptian Goose range(yds)	Egyptian Goose Az(°)
2	4	8200	51.5°	8230	51.5°		
*	5			5400		5600	83°
3	6	8400	105°	8400	105.5°	8400	105°
3	7	8400	105°	8400	105.5°	8400	105°

*The truck was en route to target 3

TARGET LOCATION
Flight No. 6 Test No. 222
15 January 1971

(C) This test was conducted to compare Egyptian Goose position data with the DAME position data. A few minutes after lift-off, the Egyptian Goose transmitter failed. The flight continued to collect DAME data until video reception was lost on both TV monitors. At this point, the test was terminated. Airborne TV problems were scheduled for maintenance before the next flight. Flight altitude was 1,000 feet and flight duration was twenty-four minutes.

TARGET LOCATION
Flight No. 7 Test No. 222
18 January 1971

(C) This test was scheduled to obtain Egyptian Goose position information of selected targets and compare these data with those obtained from the DAME. Flight altitude was 1,000 feet. This was the first attempt to use an omni-directional antenna on the helicopter. The Egyptian Goose did not observe the beacon during the data "sweep" cycle. The test was cancelled at 1038 because of a power problem at Angel Peak. Flight duration was twenty-seven minutes.

TARGET LOCATION
Flight No. 8 Test No. 222
18 January 1971

(C) This test was conducted to obtain data to compare the Egyptian Goose position data with the DAME position data. The six targets were: 1, right flank tower; 2, left flank tower; 3, target #3 BM 108; 4, center North CBU; 5, Target E - ten cars; 6, center south CBU. The six targets were located

and comparative data were recorded. Results are summarized in Table C3. Flight altitude was 1,000 feet and airspeed was maintained at minimum safe at data collection points. Flight duration was sixty minutes.

TABLE C3 (Title Unclassified/Table Confidential)

EG AND DAME AZIMUTH ANGLE AND RANGE DIFFERENCES

Target	DAME Range (yds)	DAME Azimuth Angle (deg)	Range Difference (yds)	Azimuth Angle Difference (deg)
1	6225	33.0°	-60	0.5°
2	7750	16.5°	-185	-1.0°
3	8920	29.5°	-55	-2.0°
4	10680	35.0°	785	-1.5°
5	8250	52.0°	105	-1.0°
6	6500	57.0°	-135	-3.5°

TARGET LOCATION
Flight No. 9 Test No. 222
19 January 1971

(U) This test was scheduled to obtain additional position data to compare DAME and Egyptian Goose range and azimuth differences. Two runs were attempted. the first was terminated to repair TV problems and the second was cancelled because of helicopter problems. Flight duration was thirteen minutes.

TARGET LOCATION
Flight No. - Test No. -
11 February 1971

(U) This test was conducted to collect data to compare Egyptian Goose position data with the DAME position data. Nine positions of a truck target on the dry lake bed were plotted for range and bearing by both DAME and the Egyptian Goose and recorded on the plotting board in the ground control station.

TARGET LOCATION
Flight No. - Test No. -
25 February 1971

(C) This test was conducted for the purpose of obtaining and evaluating position data of various targets. Egyptian Goose monitored three LARS helicopter flights and two low level aircraft (F-4) detection flights. A special Westinghouse engineering test and a maximum range detection test were supported. The system performance in all tests was good and data were obtained on all operations.

EQUIPMENT EVALUATION
Flight No. 10 Test No. 346 & 347
22 October 1971

(C) This test was conducted for the purpose of evaluating the Grand View operation on mid and max-range flights. Helicopter position information was supplied by the Egyptian Goose system and displayed to the flight controller for navigation purposes. The helicopter was able to mark two towers, then the test was cancelled when the Egyptian Goose beacon failed due to a faulty connection on the aircraft.

EQUIPMENT EVALUATION
Flight No. 11 Test No. 343
9 November 1971

(C) This test was conducted for the purpose of evaluating mid-range operation of the Grand View and the Egyptian Goose. The helicopter telemetry and TV systems were placed in relay mode at 6,000 yards from the launch area. Beacon returns were lost when the helicopter made heading changes. These tests show that portions of the air frame are shielding the beacon and that it should be relocated to provide continuous coverage. Flight duration was sixty minutes.

EQUIPMENT EVALUATION
Flight No. 12 Test No. -
10 November 1971

(C) This test was conducted to evaluate the relocated Egyptian Goose beacon antenna on the helicopter. The helicopter was flown at 500 and 1,000 feet altitudes. The relocated beacon antenna provided adequate signal for all helicopter altitudes and headings.

EQUIPMENT EVALUATION
Flight No. 13 Test No. 343 & 347
11 November 1971

(C) This test was conducted to evaluate the mid-range and max-range capability of the Grand View and Egyptian Goose systems. The telemetry and the TV signals were poor in the relay mode. The aircraft was flown in the direct mode to within two miles of the target which was at a range of thirty-eight miles from the radar site. The Egyptian Goose provided helicopter position information.

EQUIPMENT EVALUATION
Flight No. 14 Test No. 343 & 347
12 November 1971

(C) This test was conducted to evaluate the mid-range and max-range capability of the Grand View and Egyptian Goose systems. The max-range test was canceled because equipment repair could not be made in time. A short range flight was flown in the relay mode. Severe telemetry noise was observed. Helicopter position information was provided by the Egyptian Goose radar.

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GLOSSARY

A/C	Aircraft
AEC	Atomic Energy Commission
AGC	Automatic Gain Control
AM	Amplitude Modulation
ARPA	Advanced Research Projects Agency
A/S	Airspeed
CBU	Cluster Bomb Unit
CRT	Cathode Ray Tube
CT/FCC	Contrast Tracker/Fire Control Computer
CW	Continuous Wave
DAME	Distance and Azimuth Measuring Equipment
ECOM	Electronic Command
EG	Egyptian Goose
E-O	Electro-Optical
EOD	Explosive Ordnance Disposal
FAA	Federal Aviation Agency
FFAR	Folded Fin Aerial Rocket
FM	Frequency Modulation
GCA	Gyrodyne Company of America
HE	High Explosive
HV	Hypervelocity
IF	Intermediate Frequency
IFLOT	Intermediate Focal Length Optical Tracker
ILS	International Laser Systems

ITT	International Telephone and Telegraph
KVA	Kilovolt-ampere
LARS	Laser Aided Rocket System
LLLTV	Low Light Level Television
MDS	Minimum Discernible Signal
MTI	Moving Target Indicator
OD	Olive Drab
PAM	Pulse Amplitude Modulation
PLG	Proportional Lead Guidance
PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency
PTP	Peak to Peak
RF	Radio Frequency
RFI	Radio Frequency Interference
RMS	Root-Mean-Square
SR	Slant Range
SS	Signal Strength
TLM	Telemetry
UHF	Ultra High Frequency
VFO	Variable Frequency Oscillator
VHF	Very High Frequency
W/H	Warhead